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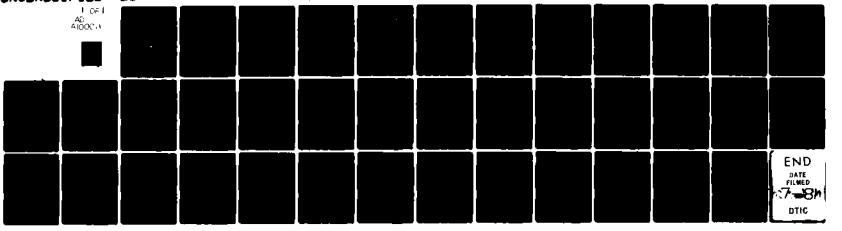

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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the Scientific Literature) may prove of value to American scientists by calling attention to current developments and to institutions and individuals engaged in these scientific efforts.

The articles are written primarily by members of the staff of ONRL and occasionally articles are prepared by, or in cooperation with, members of the

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CHEMISTRY

PHOTOCHEMICAL RESEARCH AT THE ROYAL INSTITUTION

The Royal Institution (RI) was founded in London in 1799 by Benjamin Thompson, Count Rumford, to apply basic science to the practical needs of society through research and experimentation. The RI developed into a place at which not only was research conducted, but also science and the latest discoveries were announced and interpreted to laymen. In 1826, Michael Faraday began the Evening Discourses, a series of lectures for scientists and interested laymen covering all aspects of science and technology. These lectures continue today essentially in their original form and are always well attended. Subjects covered by guest lecturers during the last year included such diverse topics as: physical basis of vision, miniaturization of electronic components, elementary particles and forces, genetic engineering, modern methods of crime detection, earthquakes, bioluminescence, and solar cells.

The RI has, since its founding, been an independent organization with no direct financial support from the government. It depends on the subscriptions of its members (membership in the Society is open to all), charitable donations, and income from endowments in order to carry out its educational activities. The research programs at the RI receive support from a variety of sources including the Science Research Council.

Many of Britain's great scientists have made important discoveries in the laboratories at the RI: Sir Humphrey Davy discovered Na, K, Ca, Sr, Ba, and Mg; Michael Faraday, probably England's greatest experimental scientist, discovered electromagnetic induction, elucidated the laws of electrolysis, and isolated benzene; John Tyndal studied the scattering of light by small particles; Lord Raleigh discovered argon and carried out his classic work on diffraction gratings and the polarization of light; Sir James Dewar liquified hydrogen; Sir William Bragg discovered X-ray spectra and with his son, Sir Lawrence Bragg, co-founded X-ray crystallography, a technique for structure analysis for which they received the Nobel Prize in Physics in 1915. Sir Lawrence used X-ray analysis to obtain the first structures of proteins, myoglobin and hemoglobin, and of the enzyme, lysozyme.

In 1966 Sir George Porter, who shared the Nobel Prize in Chemistry in 1967 with M. Eigen and R.G.W. Norrish for his work in the development of flash photolytic techniques, moved from the University of Sheffield to become the present director and resident professor at the RI. Prof. David Phillips has recently come to the RI with his group from the University of Southampton as Wolfson Professor of Natural Philosophy. The research in progress in the Davy Faraday Research Laboratory (the independent research laboratory at the RI) is under the overall direction of Porter and Phillips. While the research programs of the two groups have a somewhat different emphasis, both groups are involved in the general area of photochemistry. These groups work closely together sharing facilities and holding joint research discussions. The research of Porter's group is in the areas of (1) picosecond kinetics of primary photophysical processes and (2) model systems for photosynthesis. Phillips' group is primarily concerned with (1) the application of time-resolved fluorescence spectroscopy to the study of molecular motion in synthetic polymers and biopolymers, (2) studies of oxidation using low light level chemiluminescence techniques, and (3) gas phase photophysics. A brief review of a few of the interesting research projects in both groups is given below.

Most of the research in Porter's group on picosecond kinetics is supervised by Dr. Godfrey Beddard except for experiments with a Nd laser/streak camera system that are directed by Dr. Alex Osborne. Beddard in collaboration with T.A.M. Doust has been using the technique of "frequency upconversion" to measure fluorescence lifetimes on a picosecond time scale. In this technique, which uses the nonlinear optical phenomenon of sum frequency generation in anisotropic crystals, a sample is excited with a picosecond laser pulse and the resulting fluorescence from a sample is focused together with a time-delayed portion of the laser pulse into the crystal. Light of frequency ω_3 ($\omega_3 = \omega_1 + \omega_2$) can be detected ($\omega_1$ is the fluorescence frequency and ω_2 is the laser frequency). Since the intensity of the sum frequency ω_3 is proportional to the product of the intensities of ω_1 and ω_2, one can obtain a decay profile of the fluorescence by varying the path length of the delayed laser pulse. Experiments by this group have utilized a laser excitation source consisting of a CW rhodamine 6G dye laser (Coherent Radiation CR 590) which is synchronously pumped by an actively mode-locked argon ion laser. Pulses <10 ps duration at 590 nm can be produced. Use of this laser technique permits

fluorescence from 600 to 1,000 nm, where photomultiplier tube sensitivity is low, to be upconverted to 300 to 370 nm where photomultiplier sensitivity is high. By deconvolution of the observed decay signal for the autocorrelation function of the laser pulse, fluorescence decay times <10 ps can be determined. This resolution is an order of magnitude better than single photon counting techniques and comparable to that of a streak camera. In some experiments polarized excitation light is used and subsequent fluorescence depolarization due to rotational diffusion and energy transfer is measured. Beddard, Doust, and Prof. M.W. Windsor (Washington State Univ.) have recently used fluorescence upconversion techniques to study the relaxation of the S_1 state of triphenylmethane dyes such as crystal violet and malachite green. The fluorescence quantum yields and decay rates of these dyes are both found to be dependent on solvent viscosity. These observations have been interpreted in terms of a model in which rotational relaxation of the phenyl rings in the excited state is effected by the viscous drag of the solvent.

Beddard, A.C. Winkworth, and Dr. P. Heathcote have studied the infrared fluorescence of bacteriochlorophyll from whole cells of the green photosynthetic bacterium, *chlorobium*. Using upconversion techniques with the mode-locked argon ion laser and synchronously pumped dye laser, they have been able to show that the fluorescence decay rates were a function of emission wavelength, indicating that energy transfer processes are involved. In a related study, these workers have compared the fluorescence decay rates of chloroplasts from lettuce, peas, and spinach. In each case the fluorescence decays were more than doubly exponential. Further, the various corresponding fluorescence lifetimes differed significantly indicating that energy-transfer processes were, in fact, not alike in the chloroplasts obtained from these three sources. In an interesting series of experiments these workers found that lettuce chloroplasts with varying (chlorophyll a)/(chlorophyll b) ratios (selected by using older outer leaves or new inner leaves in the preparation) exhibited fluorescence lifetimes which were a function of this ratio. They observed that the older leaves with more chlorophyll b gave longer fluorescence decays.

Beddard and Dr. C.D. Tran have investigated photophysical processes of bilirubin bound to bovine serum albumin, human serum albumin, or vesicles of dioctadecyldimethylammonium chloride. Both picosecond time-resolved fluorescence spectroscopy and circularly polarized luminescence techniques have been used. They have found that bilirubin shows double exponential decay of the fluorescence in all three environments with >99% of the emission at 525 nm occurring from the shorter-lived component (69 to 98 ps) and <1% from the longer-lived component (1 to 2.1 μsec). However, at an emission wavelength of 575 nm the fraction of the longer-lived component increases to ∿1.3%. Prior irradiation, for one hour, of bilirubin bound to the surfactant vesicles was found to result in an increase in the contribution to the fluorescence by the longer-lived component to 4.1%. This effect was found to be reversible upon storage of the irradiated vesicles in the dark at 5°C. These results and those of a study of circularly polarized luminescence indicate that there are two emitting excited state species, one of which has the same conformation as the ground state and emits at <530 nm. It is concluded that an excited state species with a conformation distinct from that of the ground state emits at longer wavelengths. These workers have interpreted these results as evidence for the photoisomerization of bilirubin from its ground state Z-Z conformation to Z-E, E-Z, and E-E isomers.

Beddard and Dr. R.J. Cherry (Eidgenössiche Technische Hochschule, Zurich) have collaborated on a study of molecular motions and interactions on the surface of human erythrocytes using a chemically-attached fluorescent probe molecule. Selective oxidation of sialic acid or galactose residues of oligosaccharide side chains of the glycoproteins and glycolipids that are present in the membrane produces aldehydic groups. Subsequent reaction with the fluorescent probe, eosin 5-thiosemicarbazide, yields the labeled erythrocytes. Time-resolved fluorescence depolarization following picosecond laser excitation has been used to study fast molecular motion. Beddard and Cherry observed that both eosin-labeled sialic acid and galactose residues exhibit a rapid motion with a correlation time of approximately 3 ns. This motion has been assigned to a localized independent motion of the eosin probe, possibly associated with a short segment of the oligosaccharide chain. Slower motions of the probe have been investigated by observing microsecond transient dichroism. This second, slower motion has been ascribed to cooperative motion of the oligosaccharide chains. These measurements provide a method for analyzing the dynamic properties of cell

surfaces and could be of particular interest in investigations of the effects of agents such as antibodies and viruses which interact with glycoproteins and glycolipids on the cell surface.

The second major area of research in Porter's group involves investigations of model systems for photosynthesis. These studies which are supervised by Dr. Anthony Harriman are directed towards the development of methods for solar energy conversion through the photodissociation of water by visible light into hydrogen and oxygen. Much of the work in this area recently has dealt with the possible use of the metal porphyrins as photosensitizers for the reaction. A wide variety of these metal complexes have been synthesized and their photophysical properties studied in detail. Metalloporphyrins are believed to be potentially quite useful as photosensitizers for water-splitting as they absorb strongly in the visible region, are relatively inexpensive, and are known to undergo photoredox reactions with added electron donors or acceptors. Further, the redox potentials of the metalloporphyrins are such that they may be able to effect the production of hydrogen and oxygen from water. The nature of the central metal atom influences the ground state absorption of the porphyrins as well as the lifetimes of the excited singlet and triplet states.

Harriman and P. Douglas are involved in a study of Cd(II) porphyrins which have properties similar to the previously investigated Zn(II) porphyrins but exhibit higher quantum yields for the formation of the triplet excited state. A water-soluble sulfonated Cd(II) porphyrin derivative has been prepared which seems to hold considerable promise in the photoreduction of methyl viologen *via* a sacrificial system. These workers are also investigating possible oxygen production using Mn porphyrins. These sensitizers are of particular interest because of the role Mn plays in the natural photosynthetic process in green plants in which an Mn complex is thought to catalyze the oxidation of water to oxygen.

As part of the program on photochemical water-splitting, Harriman and A. Mills have constructed a two-electrode, membrane polarographic detector for the quantitative analysis of low concentrations of hydrogen and oxygen in aqueous solution. This instrument shows good stability, short response times, and provides linear correlations of hydrogen and oxygen concentrations over three orders of magnitude.

While the photosensitized production of hydrogen from water has now been accomplished with reasonably high efficiency by this group at the RI, as well as by other investigators, the photooxidation of water to oxygen is more problematic; very few sacrificial systems yield oxygen upon illumination with visible light. Harriman and P.C. Walters have recently studied the bipy$_3$Ru^{2+} photosensitized irreversible reduction of electron acceptors such as $S_2O_8^{2-}$ and $Co(NH_3)_5Cl^{2+}$. Subsequent reaction of the oxidized form of the sensitizer with water affords oxygen. As part of these studies, two types of catalysts, colloidal RuO_2 and soluble Co^{2+} ions, are being tested for enhanced oxygen production in aqueous solution. Kinetic studies on these catalysts are being carried out in order to evaluate whether reversible acceptors can be used in place of the sacrificial components.

A major area of research for the Phillips' group involves the use of time-resolved fluorescence to study molecular motion in synthetic polymers. For this work the polymers are synthesized with pendant fluorescent groups such as benzene, naphthalene, or carbazole attached to the polymer backbone. Fluorescence anisotropy measurements on these systems provide additional insight into the nature of the molecular motion in polymers.

Phillips and Dr. D.V. O'Connor are presently investigating the interactions in a homopolymer of 2-(9-carbazolyl)ethyl methacrylate and in a copolymer of this substrate with methyl methacrylate dimethylterephthalate. These polymers have been studied in dilute solutions of benzene, methylene chloride and tetrahydrofuran. Unlike poly(N-vinyl)carbazole, this homopolymer does not show spectral evidence for excimer formation. However, measurements of the fluorescence decay using a frequency-doubled synchronously pumped dye laser and single photon counting techniques exhibit two decay times. These results indicate that excimers are formed in the homopolymer even though its fluorescence is too weak to be detected on a conventional fluorometer. In contrast, the fluorescence spectra of the copolymer exhibits two solvent-dependent exiplex emissions. Decay time measurements on the copolymer have been carried out with a hydrogen flash lamp with triple exponential decays observed.

Phillips, A.J. Roberts, and Dr. I. Soutar (Heriot-Watt Univ.) have studied intramolecular excimer formation in several polymers containing aromatic groups (poly[1-vinylnaphthalene], polyacenaphthylene and poly[N-vinyl]carbazole) using time-resolved fluorescence spectroscopy. They have also investigated a series of copolymers in which the intra-

molecular concentration of a chromophore was varied. The decay kinetics of the fluorescence have indicated that the previously accepted kinetic scheme for intramolecular excimer formation in macromolecules, derived by analogy with that for intermolecular processes in small molecules, is inappropriate. They have proposed an alternative scheme which involves a heterogeneous distribution of chromophores in the polymer. These studies are continuing with an evaluation of the effects of polymer tacticity on intramolecular excimer formation. Time-resolved fluorescence depolarization measurements will be used to characterize segmental motions which occur in polymers.

Phillips, J.R. Darwent, and I. McCubbin are investigating the photophysical and photochemical properties of water-soluble metallophthalocyanines. These substrates can function both as sensitizers for electron-transfer reactions with selected acceptors and for energy transfer to oxygen to generate singlet oxygen. Fluorescence lifetimes have been determined in solution using a synchronously pumped dye-laser system. This fluorescence was found to be quenched efficiently by both electron donors (hydroquinones) and electron acceptors (viologens). The triplet excited state was also quenched by these compounds and sulphonated anthraquinones; heavy atom quenching using bromide and iodide ion was found to be negligible.

In summary, it is evident that the Royal Institution today under the direction of Sir George Porter continues in the tradition of Faraday with significant contributions to the understanding and appreciation of science by laymen and with research at the frontier of an important area of science. The results of the research now in progress at the RI will undoubtedly play a major role in the solution of important problems such as solar energy conversion.
(A. Paul Schaap)

EDUCATION

THE SCIENCE OF ACTION

The Institut Auguste Compte "pour L'Etude des Sciences de L'Action" in Paris translates literally as "for the study of the sciences of the action." It is a school, and I was told by one of my informants, "it may not be better or worse than other schools but it is surely different."

The tuition for the 1-year course (from September through July) is 100,000 francs. Living expenses are not included in this figure. (The costs to the school are exceedingly high—some of them are described below—and there is actually a good deal of additional support from the government over and above what is collected in tuition.) While the institute is, indeed, expensive by its very nature, this incredibly high tuition can only be understood with the knowledge that an early management decision was made to have the highest tuition in the world as one of the methods of attaining prestige. There are about 50 students, mostly in their early 30s, all with considerable experience and considerable promise. They are sent to this institute by their employers, who may be industry, the government itself, or the so-called national enterprises (e.g., the railroad system) which are run by the government.

The institute was started in 1978 at the personal instigation of President Giscard D'Estaing on the ground that the existing management schools were not turning out the kinds of talent needed. Giscard D'Estaing personally appoints not only the head of the institute, but the entire board of directors. The head is Michel Lafon, who was with the Ministry of Telecommunications. The chairman of the board is Roger Martin who was chairman of the board of St. Gobain Pont à Mousson, a large French organization manufacturing industrial raw materials. There are also representatives on the board from several of the ministries, especially those which provide funding and send students. First among these is Defense, but the Ministries of Agriculture, Education, and Equipment (the Ministry of Equipment is responsible for roads and buildings) are also represented. In addition, the heads of some other schools, but not schools of management, are members of the board. This is explicitly not a school of management.

The institute occupies the buildings of the old Ecole Polytechnique, a famous French institution which has expanded to the point that it was forced to leave its old facilities and move to the suburbs. Most of the students are engineers who have had technical positions and are attempting to gain a broader view during their year of instruction, in addition to learning how to "take action." Half of each student's time is spent on a project; all of these projects are action-oriented, being designed not like projects in

most other European schools (*ESN* 32-12: 428 [1978]) but to make something go. Several typical projects are described below. One quarter of the time is spent in "personal development" including foreign languages, sports, public speaking, how to run a meeting, and even such things as personal medical care. The remaining quarter of the time is spent in the more conventional educational activities of lectures and conferences; there are never any grades or examinations.

The lectures and conferences are organized largely into five "lines" or courses: decision science, international affairs, sociology of organizations, economics, and environment. Most of these titles are somewhat misleading, as will be seen. The head of each course is usually a very important person from outside the organization who works at the institute on a part-time basis for one or two years, and is chosen largely for his network of contacts, influence, and his ability to bring in recognized and useful guest lecturers. The guest lecturer is typically the chief executive officer of a large organization or a corresponding person in government. A small group of students works with the lecturer before the presentation, discussing the subject and how it will be handled. In most cases students devote some time to studying the problem before attending the lecture. There may be three or four such lectures a week, but not all students attend every lecture because many of them are away working on their projects or involved in their "ateliers," or workshops. Students are able to promote activities of their own; for example, one is a naval officer who has decided to organize a 2-day conference or workshop on French defense, and is bringing a number of high-ranking people from the military to speak at this conference.

The manager of the decision science course is J. Lesourne, whose publications on likely developments in the 1980s and 1990s have been well received in France. This course is not at all like "decision science" curricula in most universities; typically, in addition to futurism, there are lectures on how to find and select a consultant, and the managers of the largest consulting firms in France come and discuss their methods. The head of the international affairs course is J. Maisonrouge, the chairman of the IBM World Trade Corporation. M. Crozier, who heads the sociology of organizations course, is one of the best-known sociologists in the world. Much of the content of this course is on organization behavior, which is especially important because it is often inadequately considered by the students (who have primarily been trained in engineering). The course also covers the economics and legal aspects of such things as unions; typically the lecturers include high-ranking labor leaders.

The course on economics is headed by G.E. Worms who is the president of Hachett, the largest French publishing company. Again there is none of the usual content of elementary microeconomics or macroeconomics courses which involve mathematical theory. Here people talk about things like inflation; or they pick some particular strategic material such as cobalt or manganese and discuss the availability and requirements of such materials in France. There are also some lectures on finance. Economics is the largest course, and Worms has three assistants whereas most of the courses have only one or two. Finally, the environment course is headed by M. Michardiere, the head of the Cour des Comptes, the French equivalent of our General Accounting Office. While there is some study of what is commonly called environment in America (that is, questions of pollution and how to avoid it), most of the course is about the environment of business and other large organizations. Typically, for example, the class goes to the mayor of a small town outside Paris and talks to him about his problems. A few other topics are selected near the beginning of the year. In this selection, as in most everything else, the students participate. This year, these problems include the problem of forests in France and the problem of harbors.

I talked at considerable length to Joël Malkin, an assistant in the economics course, who teaches the material on finance and also runs three projects. Malkin received his diploma in engineering from the Ecole Centrale in 1962, the MBA from the Graduate School of Management at Northwestern University in 1972, and the PhD in finance from the same school in 1977 (having spent most of the intervening time in France). Nominally, he spends half of his time at the institute and half at the Ecole Centrale where he holds the rank of professor, but in fact he spends most of his time at the institute, especially because the supervision of projects is so time consuming. Each of his three project has three students.

France, like almost all developed countries, has a severe balance-of-

payments problem. The leading contributor to these deficits is of course petroleum and petroleum products, but surprisingly the second is wood, furniture, paper, and related products, and the third is soybeans, edible oils, and related products. Two of Malkin's projects are related to the second and third categories.

Edible oils and cattle feed are closely related, because in general one takes the appropriate oil-bearing materials, usually the seeds of plants, and squeezes them to extract the oil; the cake which is left then becomes cattle feed. France is capable of producing—and does produce in small quantities—colza and sunflower seeds which are quite adequate sources of these materials, but apparently continues to import enormous quantities of soybeans and other edible oil sources from the US and from Brazil. Malkin and his students have been working primarily through CNTA (National Center for Agricultural Techniques), a private company whose stockholders are agricultural cooperatives. "We ask people why they don't like colza oil and we ask cows why they don't like colza cake," said Malkin, adding that the latter was really a joke. Apparently there were some chemicals in colza oil which were implicated in heart disease. New strains of colza have been developed which do not have these chemicals; but colza still has a bad image in France, and part of the problem of this project is how to alter this image. Furthermore, both cows and the farmers who own them are conservative, and prefer to stay with the feedstuff that they know, namely soy cake, rather than changing to colza cake. There is thus a marketing strategy to be designed. Apparently the Canadians have been very successful in growing and marketing colza, and the students in this project will make a trip to Canada to attempt to find out how this is done; they will then return to France and initiate the appropriate marketing schemes. This is typical of all projects at the institute, which invariably have an international aspect and always require a great deal of travel—one of the reasons why the course is so expensive.

The project involving the paper industry is concentrated on the southwestern portion of France (south of Bordeaux) which is a large consumer of petroleum. The students in this project are attempting to find methods of lowering this consumption. While the study is centered around the paper industry, whatever results they achieve can obviously be transferred to other French industries. The project requires not only a study of technology and economics, but also of sociology, because the ownership of the forests that are involved is in the hands of many different local French people and some of these private owners may be reluctant to cooperate in the study. One aspect on which they are working is to use the stumps of trees as a source of energy. These are usually abandoned or burned or pulverized and left *in situ*. Apparently there are methods of getting such stumps out and using them as fuel; they plan to visit wood technology organizations in both Finland and the US to find out how this is done. They are also looking into the use of agricultural wastes. There are two ways of recovering energy from these. One is the "moist" method, which is biological fermentation, to create fuel gases such as methane. The other is "dry," which involves putting the material into something like a coke oven where it is heated to yield charcoal and possibly some gaseous or liquid fuels. In California, there is apparently a mobile device for utilizing such wastes by the dry method. This device converts all types of agricultural wastes into fuel right in the fields. The project members will travel to California to study the device while they are visiting the US to look at forest machinery.

The third project was especially interesting. It involves a device for handling electronic money. There are, as is well known, a number of proposals for the "cashless society." This one is a little different from all the others. The customer is given a plastic card which includes a chip with a significant memory and some computing capability. When the customer buys something at a store, the card is inserted into the appropriate machine at the store and the transaction is recorded. The difference between this approach and other schemes is that there is no connection to the bank of either the purchaser or the vendor, at the time of the transaction. The card is initially charged at the bank, by insertion into an appropriate machine there, with however much money the owner wishes to withdraw from his account and put into the card. In each subsequent transaction, the appropriate amount is subtracted from the balance held by the card. Meanwhile, the machine at the vendor's store simply accumulates all the transactions in its cassette, whence they are sent to the bank at the end of the day. The project group is working with the French Association of Banks to promote this. They are planning an experiment in the city of Lyons early in 1982 in which 2,000 people will receive these cards and from 100 to 200 stores will be

equipped with the appropriate machine. The project group is planning first to go both to the US and to Japan to talk to people there about systems in those countries, and then to spend much time in Lyons arranging for the actual installation of their own experimental system. The system is supposed to be highly resistant to forgery or other compromise.

This institute appears to have been very successful in what it has attempted thus far, not necessarily by any objective measures, since there seems to be no objective way to evaluate it, but simply because the board, the faculty, and the students all think it has been successful. An evaluation of the institute was also provided by a "competing" educator, a senior member of the staff of one of France's *Grandes Ecoles*. He indicated that the institute and its students are regarded with the same awe in the science and technology segment of the French educational system as the Ecole Nationale d'Administration (ENA) and its students are regarded in the political, economic, and diplomatic segments. (Giscard d'Estaing is an alumnus of ENA). In both cases, the students are very carefully screened for entrance; in both cases, the students are expected to become the leaders or first-line executives in their respective organizations. They are the people to watch as future policy makers.

There are significant expansion plans underway to establish a research center and new educational programs. Nobody I spoke to knew exactly what kind of research such an institute should do, but it surely will not be basic research. Again, nobody seemed certain what additional kinds of instructional programs should be included, but one under discussion at the time of my visit was to take research workers from universities and government laboratories, who have, over a number of years, been doing fine research and give them suitable training to enable them to transfer to industrial laboratories where greater research capability is needed.

While new management schools have been set up throughout most of the world over the past 10 or 15 years, this is the only school of its type that I know of. It will be interesting to see whether it survives in France and how it changes and matures.
(Robert E. Machol)

ENERGY

SOLAR ENERGY IN ISRAEL

Some 20 km south of Elat there is a natural pond separated from the Red Sea by a narrow strip of beach. It is a very special pond with very special properties. An unwary swimmer would find that the water a little below the surface is scalding hot. The pond is a natural reservoir of solar energy. It is oval in shape, about 150 m by 60 m and about 5 m deep. It is so unique that about 200 scientific papers have been published concerning the biological and physical processes going on within it. More papers have been written per unit volume of water in this pond than for any other body of water in the world. This is because artificial ponds are now being constructed for the active exploitation of solar energy.

Dr. Yehuda Cohen, a marine biologist, has a 10-year-long association with the solar salt ponds, as they are called. He is with the Marine Biological Institute of Elat in Israel, which is part of the Hebrew University of Jerusalem. He explained that the pond's heating is due to the greenhouse effect. The water in the pond evaporates rapidly due to the high local evaporation rate (up to 4 m per annum), but it is replenished with fresh sea water. The shallow pond is close to the shoreline and its water level is a little higher than that of the Gulf of Elat. The near-surface distribution of sediments between the pond and the gulf is such that water is drawn by capillary action from the gulf up and over the slight ridge between the gulf and the pond and slowly trickles into the pond. The continuous evaporation of water leaves the salt behind and the liquid in the pond is a very dense brine. The lake is mixed from top to bottom during the months of July and August when the evaporation rate is the greatest. During the remaining 10 months of the year it is stratified. The surface layer has salinities ranging from 5 to 6% (50 to 60 o/oo in oceanographic terms) and the bottom layer has salinities of 17 to 18% (170 to 180 o/oo). The 2 layers are stably separated by the steep gradient of density between them. The pond is sheltered from wind on 3 sides by steep, high hills that tend to reduce wind mixing to a minimum. Radiation from the sun is absorbed by the hypersaline solution which in turn heats up. It is thermally insulated by the fresher water which

prevents convection and its temperature therefore increases. Temperatures of 70°C are reached in the lower hypersaline solution. Surprisingly, the rather severe environment encourages the growth of blue-green algae (which are called algae rather for historical reasons than with correctness since they are single-celled and more like bacteria than algae). Debris from the algae fall to the bottom of the pond and form a sediment called stromatolites. Oxygen is absent at the bottom and H_2S is formed. According to Cohen, sludges of this sort might well have been the origin of oil. They are found in pre-Cambrian formations some 3.6 billion years old. Blue-green algae are found in some of the oldest fossils we have and may well have been the organisms that initially produced the first free oxygen.

An Israeli government-sponsored program is now underway to exploit the solar energy reservoir of the ponds. The engineering work is carried out by the Solmat Company from Jerusalem, a subsidiary of the Ormat Company, which was founded by Y. Bronicki, a pioneer in this field, and which primarily builds turbines specially adapted for this purpose. The present work follows earlier attempts by Ing. Tavor in the 1950s.

The Solmat Company has built an experimental station near En Boqeq on the Dead Sea. It utilizes an artificial pond having a surface area of about 1,000 m^2, and uses brine from the Dead Sea. This brine has the advantage of immediate high salinity, and contains chemicals (potash and bromides) that tend to reduce the growth of algae.

Bronicki's turbines use a closed gas system to convert the thermal energy difference to mechanical energy and then, with a generator, into electricity. The gas used is Freon which has a low boiling point (70°C) and is brought to boil in a heat exchanger with the hot brine from the pond. Ideally, the brine is extracted at 80°C and returned to the pond after a 5°C drop. The gas vaporizes, expands, and drives the turbine. It is then cooled and condensed by the cooler surface water of the pond and the cycle is repeated. The present installation, with its 1,000 m^2 pond, can generate 150 kW. This type of plant can readily be switched on and off and its best use is probably that of supplementing electric power for peak demands. (Systems using steam generation cannot readily be switched on and off.) The solar energy received during the idle periods is stored in the brine. By taking care of the peak requirements, the primary electricity supply system can be designed to be smaller and to operate more efficiently. A larger installation, 120,000 m^2, is presently planned for En Boqeq with a capability of 2 MW of power. A different, small system, similarly using solar energy, exists in the same area and supplies the heat necessary to operate the air conditioner of a large local hotel which caters to people who visit the Dead Sea to bathe in it as a medical treatment for some forms of skin disease.

The Dead Sea in the area of En Boqeq has almost dried up. This is due to the great use of the river Jordan for irrigation, leaving less water to flow into the Dead Sea than evaporates. As a result of this, the water level has dropped some 8 m in the last 10 years, and a dry stretch has developed between the upper and the lower parts. An artificial channel presently supplies water to the shallow southern parts. Even so, the various salts and chemicals separate out of the brine sequentially and can be seen looking like blocks of ice sticking out of the water.

There is much planning and study going on in Israel (in fact the majority of all the water-oriented laboratories have research programs) on channeling Mediterranean sea water into the Dead Sea. The head (1300 ft) would be used to generate large amounts of electrical power. If practical, vast, shallow ponds will be built on the mud flats south of the Dead Sea. Dead Sea water with its salinity of 30% (300 o/oo) will be used to partially fill the ponds. Then a layer of Mediterranean sea water with a salinity of only 3.9% (39 o/oo) will be used to fill the ponds. It is estimated that these artificial solar ponds will give rise to temperatures up to 100°C, much higher temperatures than those of the natural solar pond near Elat. Heat exchangers and closed cycle turbines will be used to generate electricity.

One of the biggest benefits of large artificial solar ponds near the Dead Sea will come from the increase in the area of the water surface giving rise to evaporation which in turn will allow more water to be brought in and increase the power generation without unduly raising the water level.

In order to function, solar ponds have to remain clear, as turbidity reflects light and turbid ponds lose efficiency. Similarly, they should be clear of algae, since algae decrease the penetration of light and thus reduce the efficiency. Cohen's major problem is to determine ways of eliminating both turbidity and the growth of algae.

Cohen runs an experimental solar salt pond in Elat. The pond is among the salt pans used locally for deriving salt from sea water by evaporation and the required brine is obtained during the salt-making process. Various algae-repressing techniques are tried and the pond is instrumented with gauges at various depths. Temperature losses were found to be highly correlated with algae build-up. For demonstration, Cohen pumped some hot brine. It felt slippery, almost slimy to the touch, and the temperature was high, which, by then, was not unexpected, but was, nevertheless, difficult to accept. The surface of the pond had a net floating on it to reduce mixing of the layers due to wind agitation.

Before leaving, we saw the experimental salt-water garden of the institute. It is only a year old, but full of luscious, green shrubs and bushes. The secret, it seems, is to have a well-drained, sandy soil and to water the soil plentifully with sea water. This prevents the accumulation of salt due to evaporation. Fertilizer is added to the water. Various livestock can accept the shrubs as fodder, and in fact, its rich mineral content is claimed to be beneficial.

Presently, solar salt ponds hold much promise as realizable sources of solar energy and as such are being studied also in the western US. The subject has recently been described in the *Smithsonian* (October 1980), and *IEEE Spectrum* (February 1981), and has previously been discussed in these pages (*ESN* 34-4:173 [1980] and *ESN* 35-1:28 [1981]). (T.C. Cheston and Wayne V. Burt)

ENGINEERING

DATA ACQUISITION AND ANALYSIS CAN BE VERY PROFITABLE—SERVICE TECHNIQUE
SCHLUMBERGER (STS), PARIS

STS is a development and service activity for the Eastern Hemisphere and South American (EHS) operations of the parent company, Schlumberger Ltd., headquartered in New York. EHS is based in Paris, France, whereas the North American operations (NAS) headquarters is in Houston. The oilfield data services provided by EHS and NAS represent over $2 billion in 1980 sales and contributed $500 million to Schlumberger's corporate profits. Although both EHS and NAS are jointly developing, procuring, manufacturing and distributing sensors (known as "down-hole" tools), data acquisition equipment, computer hardware and software, the functions they perform are actually somewhat separate. NAS is responsible primarily for sensors and data acquisition equipment. EHS has the world-wide responsibility for data processing hardware and software. For instance, display software developed in Houston is tested and integrated in Paris and then released for field use. Software maintenance and configuration control are performed in Paris.

A down-hole instrument at the end of a "wireline" is used to measure physical properties of underground formations. These measurements are transmitted via the wireline to a mobile surface laboratory for recording and analysis. The mobile laboratory could either be van-mounted or an integral part of an offshore drilling platform.

Oil and gas were formed from the residue of plant and animal life and accumulated in porous rocks such as sandstone and limestone. To find these reservoir rocks, it is first necessary to locate geological areas where oil may have been trapped. Seismic surveys (shock waves) give preliminary indications of structures which may contain oil but only exploratory drilling will confirm the existence of hydrocarbons. Even when a well is drilled, very little information is available to the geologist standing at the top of a hole which is several thousand feet deep and only a few inches in diameter. To gain essential insight, drilling is interrupted periodically and a mobile laboratory lowers various measuring instruments (tools) to the bottom of the drill hole on an armored electrical cable called a wireline. As the instruments are pulled out of the hole, the depth and physical properties of the various formations are measured. These measurements are transmitted to the mobile laboratory to be recorded on magnetic tape and on a strip chart graph called a "log". Interpretation of these logs determines the location and the estimate of the producible quantity of oil and gas.

At this point in the process, the oil company may have spent millions of dollars drilling the well. Wireline logs are the most reliable source of information for determining the presence of oil and gas. Yet this evaluation represents only on the average of 4% of the total cost of the well. The current charge by Schlumberger for a "3-tool" 10,000 ft. data log with 3 to 6 in. resolution is $100,000. This represents 18 hours of field work by 3 field engineers using the equipment described below.

Typical borehole measurements are based on electromagnetic, acoustic, chemical and radiation characteristics. Electrical current is passed through the formation, and the resistance is measured. When the pores of a rock are filled with salt water, the resistance is low; if the pores are filled with hydrocarbons, the rock resistance increases; consequently, electric logs are the basic measurement for locating hydrocarbons. The sonic tool transmits an acoustic wave and measures its travel time through the formation. This measurement is used for formation evaluation, determination of rocks' mechanical properties and seismic interpretation. The chemical and radiation tools investigate the atomic and nuclear structures of matter within the formation. They help determine the rock type, its porosity and the fluid composition of the formation. Several types of measurements are made: detection of natural formation radiation locates shale, irradiation of the formation by gamma rays and neutrons indicates, respectively, rock density and hydrogen content. Most radiation measurements can be made through the well casing—they are the primary diagnostic tools for "fingerprinting" new wells and evaluating them during their productive life. Measurements are made by radiating high-energy neutron pulses through the casing into the formation. The resulting thermal decay-versus-time log indicates the rate at which these neutrons are absorbed in the formation, reflecting hydrocarbon saturation. Information gathered by dipmeters helps to define the reservoir structure. Dipmeters combine multiple resistivity measurements with gyroscopes and other "navigation" devices to measure the direction and angle (dip) of the various formation layers penetrated by the wellbore. In many cases, a dipmeter analysis of one well may assist the geologist to determine where to drill the next well. A "repeat formation" tester collects samples of fluids from the reservoir rock and measures formation pressure. The pressures at which these fluids enter the tool and the types of fluids recovered help define the formation's ability to produce oil and gas.

Once hydrocarbons have been located, a steel casing is sent from the surface to the bottom of the borehole and cemented in place. This maintains the integrity of the wellbore and isolates productive formations from nonproductive ones. Typical "completion" services include: measurements to determine effectiveness of the cementing of the seal (referred to as "zone isolation"); perforation of the casing at reservoir depth to allow oil and gas to flow into the wellbore up to the surface; and logs for evaluation of the formation behind the casing. The radiation logs provide the necessary information to correlate the depth logs recorded in the cased well with the original open-hole log. Measurement of the attenuation of a sonic signal helps evaluate the effectiveness of the hydraulic seal created by the cement placed in the wellbore between the casing and the rock formations. When this log shows that the productive zone is effectively isolated, the well is ready to be "perforated." Perforating is a technique that allows hydrocarbons to flow from the reservoir into the cased wellbore. Special perforating "guns" carry explosive charges that are detonated in the borehole at reservoir depth. The exploding charges create cylindrical perforation holes in the casing and the formation, producing flow channels up to 2 feet into the reservoir rock. When flow is established, pressure from the subsurface formation must be immediately contained at the surface. These pressures can exceed 10,000 psi (700 bars). Pressure-control equipment at the surface allows retrieval of the perforating gun from the wellbore. Once this operation is completed, the well is considered tested and is put into production.

The Cyber Service Unit (CSU)

CSU is an integrated system of surface instrumentation and a materials testing laboratory built around a general-purpose digital computer. The computer, a PDP-11/34 with 65K of storage, controls the acquisition, processing, storage and presentation of log data for any combination of down-hole tools.

Once the logging program has been defined, the operator selects the corresponding software program. CSU transforms the down-hole signals and the core material test data into a form suitable for recording by the computer. The computer maintains a dialogue with the operator via the keyboard/printer and obtains the general information to perform calibrations if necessary. Calibration results are recorded both on film and magnetic tape.

When the tool is lowered to the bottom of the well, depth information is fed into the system compensating for the direction of the cable motion. The operator can observe the log curves on the video monitor with various selections of depth scale.

When the operator initiates the logging operation, the tool is raised from the bottom of the well, and the logging data, which are transmitted through the cable, are fed to the

computer. Raw data are then normalized using calibration data. Both raw and calibrated data are recorded on the tape in real time. The basic log data are also recorded on film.

At the end of each survey, while the tool is being pulled out, the data acquisition tape may be used as an input to the computer for generating a set of quality-control records and displays on the video monitor. Crossplots, histograms and listing outputs are displayed on the keyboard/printer. Crossplots display the frequency of occurrence of a pair of data output values measured or derived within a given depth for calibration checks and parameter estimates. Histograms of a single log file, on the other hand, are used to correlate with logs of adjacent or nearby wells. At this point, the operator can check registration between the depth profiles of the different logs. Also, if the calibration after the survey is found to be better than before, the log can be recomputed from raw data using the new calibration.

The CSU data-handling operation provides a thorough quality control of the logs, delivers a final product in the form of a magnetic tape, and presents quick answers to assist the geologist and the driller in formulating real-time decisions at the well-site. The method used could be adapted to local conditions. However, it generally consists of the computation of a few basic formation parameters which may agree with analagous data from nearby wells.

Data computed from a model of the formation are compared with the measured data to check the consistency of log readings from a given run or from different runs. For example, quick-look software is available at CSU to determine porosity and water saturation level; it provides estimates which are compared to quantitative evaluation of the existence of hydrocarbons.

If a telecommunication system is available near the field site, the data on the edited tape can be transmitted to a computing center where, as discussed below, a more complete analysis can be performed. During the data transmission, the integrity of the data is constantly checked by the CSU computer. Results of the more detailed analysis can likewise be transmitted back to the CSU location. However, due to the sensitivity of various petroleum states and oil companies to the privacy or secrecy aspects of the log data and the telecommunication policies of certain Western European countries, magnetic tapes are often hand-carried to the computation center.

Field Log Interpretation Center (FLIC)

Beside the quicklook interpretation which helps in real-time decision making at the well-site, a full-scale quantitative evaluation can be obtained at the nearest field interpretation center. Services currently available in a FLIC are:

- Log playbacks
- Simple log computations
- Dipmeter computation
- Log Analysis
- A more elaborate correlation between measured data and model-based estimates.

There are over a dozen FLICs located worldwide, including such locations as Singapore and Peking. More are planned. Each FLIC is equipped with PDP-11/VAX780 or-11/70 computer system. The charge for each log analysis by FLIC is approximately $6,000. The guaranteed turn-around time for this operation is 6 hours.

Advanced Computing Centers

The highest level of data processing and interpretation offers more detailed and comprehensive studies of the logging data. Services such as reservoir description services (RDS) and production management logs are provided. The RDS is an extended computer analysis which combines and compares logging data from all the wells in a given field, together with other data such as core analysis and production test results to establish a comprehensive, three-dimensional picture of the oilfield as a whole. These services are provided at two locations: Houston and Paris. The Eastern Hemisphere advanced computing center in Paris is equipped with a dual PDP-11/VAX780 system. The software for use with color displays and a 3-D graphic system is currently under development. Software generation and configuration control for the CSUs and FLICs are performed in Paris for the worldwide complex.

Except for the system's configuration control, Schlumberger thrives on decentralization of all functions. Originally, all computer processing now performed by the CSUs was done in Paris. In the past, all data processing now accomplished by the FLICs was done in Paris. The RDS functions are now in the process of being decentralized from Paris to the FLIC environment. It is anticipated that further decentralization of certain CSU functions into the tools themselves will occur when they become convinced that microprocessors are practical in the hostile environments encountered by the down-hole tools. Paris will eventually become only the worldwide software development, maintenance and configuration control center.

In order to anticipate this challenging "software logistics" problem, a satellite data network for software distribution and remote diagnostics is planned, although field data transmissions are optional for previously stated reasons. In a new program, Schlumberger is planning to expand into the seismic signal analysis field. Signal processors such as Floating Point Systems' AP120Bs are being installed in Paris to support this effort.

Marginal Return on Additional Information

As described previously, CSU data acquisition represents 4% of the total cost of drilling. FLIC regional processing costs represent 6% of the data acquisition expenditure. Any genuine improvement in processing techniques enjoys a tremendous financial leverage. Schlumberger is wise in decentralizing operational aspects of the service to CSUs and FLICs and in retaining centralized control over R&D, logistics and maintenance functions. One should not fail to note that only commercial-grade hardware is used to fulfill the high reliability requirements of the hostile oilfield environment. The merits of standardization in computer hardware and software are also obvious. Parallels can be easily drawn for military and tactical systems. Perhaps a lesson can be learned by the Navy and the DOD! (Y.S. Wu)

OCEAN BOTTOM AND RELATED INVESTIGATIONS AT THE UNIVERSITY OF BATH

The University of Bath in the west of England is a small, modern institution with only about 3,000 undergraduate students and 500 postgraduates. The Department of Physics has 130 undergraduates and 16 postgraduates. Prof. H.O. Berktay holds the chair of geophysics in the department and runs a very active research group working on underwater acoustics, with a special interest in ocean bottoms and sub-bottoms. Berktay came to Bath about 3 years ago to take over the work started some 7 years earlier by Prof. W.D. Chesterman. Prior to his appointment, he had been at the University of Birmingham where he was a leading member of that school's renowned underwater acoustics group. Berktay's group now has a permanent staff of 5 professionals, 6-7 research students, and 4-5 so-called research officers who hold special appointments under contract for work on specific projects. Each contract is reviewed yearly and, basically, terminates at the end of funding. Berktay described his group's research work, which is supported by both industry and government, the latter through a variety of its agencies such as the MOD, the Science Research Council (SRC), and the Natural Environment Council. The group also assists various small special interest firms involved in off-shore operations who come for advice or help to develop, for example, special instrumentation. Ample funding appears to be available for this work which may, in addition to laboratory work, involve sea-going operations with the development of associate instrumentation as well as bottom investigations and profiling.

Berktay introduced Dr. Victor Humphrey, a research officer, who described his work with nonlinear (parametric) acoustics. If an acoustic aperture is excited at two high frequencies so that, at each frequency, a high-power narrow beam is generated, then in the near field of the aperture, mixing of the two frequencies takes place due to the nonlinear characteristics that water displays with high power. The result is that an end-fire "aperture" is formed in the water, at the much lower (beat) difference frequency, which radiates a narrow, low-sidelobe beam. Humphrey has used this beam in the near field, where it has a small diameter, to probe materials in order to determine their acoustic transmission losses.

Instead of using two frequencies, one single carrier frequency was used, suitably pulse modulated so that the necessary spectrum was generated. The transmitting aperture was 5 cm in diameter and was energized at 1 MHz. With a difference frequency of 80 kHz, the beam was found to have a 10-cm diameter (for -10 dB points) at a distance of 50 cm. One of the problems encountered was the presence of energy at and near the carrier frequency (1 MHz). This was filtered out with a loaded rubber material that had an insertion loss of 4 dB at 100 kHz and 40 dB at 1 MHz. The experimental setup then consisted of the 5-cm-diameter transmitting aperture, a 1-cm-thick sheet forming the low-pass filter at a distance of some 50 cm from the aperture, a wide-band receiver at a distance of some 65 cm, and a sample sheet whose transmissibility could be measured by inserting it between the filter and the receiver. The sample's insertion loss could then be measured over a wide frequency band by suitably changing the transmitter modulation. To check the system, measurements were taken with a 9-mm-thick aluminum plate as a sample, and its insertion loss was obtained for frequencies from

5 to 100 kHz. The results agreed with theory, e.g., being at a maximum when the plate was one quarter wavelength thick (which presented a maximum mismatch). An experimental expanded high-density material with closed cells, EVAZOTE, was measured and found to give 30 to 50 dB insertion loss over the band. Measurements with inclined samples were also being taken and special critical-angle incident conditions were examined. Future plans include wideband transmissions with Fourier analysis and insertion phase measurements at the output and reflection coefficient measurements at the input.

Dr. Roger L. Cloet described on-going bottom topography surveys and studies of the dynamics of underwater sand banks. They used side-looking sonars capable of producing strip maps 1,000 to 1,500 m wide while being towed at 8 to 10 knots in a container known as a "fish." Various configurations of towed fish have been and are being developed with heading and roll/pitch sensors and stabilized platforms.

Apart from the side-looking sonars, a scheme is being developed that uses a vertical interferometer in the fish, operating at a frequency of about 300 kHz, to get a measure of the depth contours. Ambiguities will be resolved by the use of additional interferometer elements, additional bandwidth, or alternately, depth contours may be obtained by simple time-of-arrival measurements. Still another sonar system has been used in the fish. It uses a parabolic reflector to give an 8°-wide beam at 12 kHz and gives up to 7 to 8 m penetration of sandy bottoms.

The bottom topography of the Thames estuary has been explored and measured at 2-month intervals over a period of 2 years. Topographical maps with a 5-m grid are presently being prepared from the digitized data. Changes of several meters in depth have been found to occur, even after so short a period as 2 months, and are indicated on the grid. Position was determined with the aid of a hyperbolic navigation system, HIFIX 6, with shore stations.

Cloet also showed me some tow-cable fairings that were being developed to give low drag as well as to suppress cable-strumming. Two types of configurations were constructed; the first was equipped with stiff, plastic vanes while the second had long, continuous rubber vanes. Both were designed to rotate freely relative to the cable in order to avoid kiting. They will be tested in the near future.

Dr. N.G. Pace studies acoustic propagation through sediment. He uses a large tank, some 2 m wide, 6 m long, and 2 m deep, filled to a depth of 1 m with sand. In one experiment, he used a parametric source at 1 MHz or higher, energized by a single pulse, and, with a buried receiver, he observed the change in response in the near field as a function of angle of incidence. An extension of this technique could lead to bottom classification by means of a parametric sonar towed near the bottom. In another configuration, a study of the reflection coefficients with a parametric difference frequency of some 70 kHz could lead to a 1 m penetration of the bottom and reveal buried objects.

Another study involving the characterization of an area for laying cables was conducted for the post office telecommunications authorities in which a side-scan sonar was used to examine the seabottom. In those areas where the bottom was essentially flat, invariant, and unstructured, echo returns were obtained that were substantially determined by the sediment particle size. It was possible to group these sediments into 4 classes of sand and gravel mixtures and to recognize each group automatically with relatively simple decision rules. An automatic-classification accuracy of 78% was claimed for data obtained with a side-scan sonar towed at a speed of 13 km/hour. Work on this program is continuing.

Berktay's group is at the forefront of scientific offshore bottom investigations and constitutes an important asset for Britain's activities in this area. (T.C. Cheston)

THE ISTITUTO DI ELETTROTECNICA OF THE UNIVERSITY OF GENOA

Sometime in the near future, the Istituto di Elettrotecnica of the University of Genoa will move into a new building on the nearby engineering campus of the university. For the time being, however, it continues to occupy a modest 18th-century villa called Villa Bonino.

The institute, is made up of three main groups: Systems and Computer Science (designated SIS by them), Electronic and Biophysical Engineering (SIBE), and Electric Power Engineering (SIEP). A small separate group at the institute, GMP, works in the areas of plasma hydrodynamics and the electromagnetic characterization of dielectric materials and biological systems.

At this time, the full-time staff includes about 50 professionals (of whom 13 are full professors) and 5 technicians. In addition, some 20 professional "collaborators" (staff members from other institutes within the university, from other universities, and from nearby medical centers) participate in the Institute's research activities on a part-time basis. Teaching duties for the instructional staff of about 40 are concentrated on courses offered to the students (about 100 per year) in the last three years of the 5-year laurea program (See *ESN* 34-5:245 [1980]). The first 2-year general preparatory program in engineering, provided by the university to a total of about 300 students, is supported by this institute through its annual offerings of courses on introduction to computers for all freshmen, and introduction to circuit theory for all sophomores.

The head of the institute, Prof. G. Biorci, a renowned researcher in the field of circuit theory (See *ONRL Report* R-13-72) was not available during my visit; my host was Asst. Prof. Franco Davoli, a member of the SIS group. Davoli's special interest is the theory of large-scale communication and/or control systems. In this context, "large scale" is not necessarily meant to reflect physical size; rather it implies that the system is a multiple-input, multiple-output (MIMO) configuration with a "real" (i.e., not necessarily perfect) communication network imbedded within it as the interconnecting medium. A worldwide telecommunication system is one obvious example of a MIMO configuration; so also are the new microprocessor-based pollution-control systems on automobiles.

In a recently completed study, Davoli and two of his colleagues (Asst. Prof. G. Casalino and Prof. R. Zoppoli) considered a system model in which, at each of the control nodes in the interconnecting network, decisions are made dynamically as to which of two available modes will be used to forward the incoming data to its next (prescribed) destination. In one mode, the data will be received in *perfect* form at its next destination with respect to its present form, but it will suffer a unit time delay enroute (or in processing); in the alternate mode, the data transfer is essentially *instantaneous* but it will be flawed in some sense; e.g., the received data might be corrupted by noise, the transmission scheme might be more expensive, or both. Conclusions drawn in the study imply that optimal (or at least near-optimal) admissible decision rules can be derived under the basic assumptions that the network of decisionmakers acts as a cooperative "team" and that a suitable information exchange is set up among the decisionmakers to foster their cooperation. In this qualitative statement of the conclusions, there is no conflict with common intuition. But there is a quantitative rub: during each time interval, a computationally difficult nonlinear programming problem must be solved to select the set of optimum strategies. Some of the earlier results of this study were reported in *Large Scale Systems—Theory and Applications* (August, 1980).

Control systems are of special interest in the SIS group because one of its members, Prof. E. Volta, is head of CNR's Center for Naval Automation in Genoa. (As most readers of *ESN* know, CNR [for Consiglio Nazionale delle Richerche] is the National Research Council of Italy.) That organization studies automatic and computer-aided methods for selection of shipping routes, navigation over those routes, steering and control, and (in support of those operational activities) the development of models of disturbances which might affect them. Unfortunately, my visit to the university did not include a visit to that center.

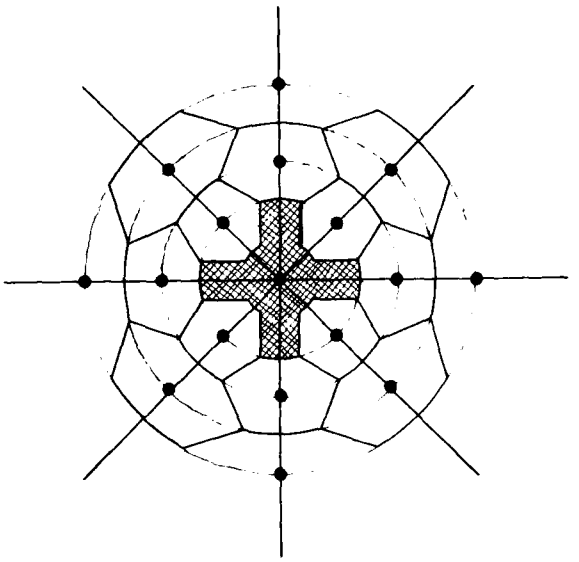
Within the SIS group, in cooperation with the SIBE group, image-processing techniques are being studied. G. Sandini, a professional researcher in SIS who is not a member of the instructional staff, showed me a most interesting demonstration of one aspect of the work in this field. The group's work on images is carried out with two distinctly different sets of goals in mind: a traditional algorithmic approach, and a bioengineering approach which they call "anthropomorphic."

The traditional approach, which is also pursued by many other research groups, is one wherein a signal that represents an image is processed in order to reduce its inherent redundancy, thereby making storage or transmission more efficient or enhancing certain features within the image (for subsequent pattern detection such as scene analysis or medical diagnosis). In those studies, the general attitude is that *any* algorithm that provides the desired data transformation is acceptable. Various algorithms, of course, are declared to be better than others—measured in terms of efficiency, computational simplicity, or image-enhancement capability. Some research at the institute continues to follow this approach; a case in point: aids in ophthalmological diagnoses from ultrasonic,

x-ray, and other image data was reported upon by Prof. V. Tagliasco, Asst. Prof. C. Braccini, and researcher G. Marino in *Computers in Ophthalmology* (April, 1979). But a different approach to image processing, anthropomorphically oriented, is also being pursued. This is part of a more general program within the institute in the area of anthropomorphic robotics. At the time of my visit, the SIS group was expecting to be notified that CNR was setting up a new center for robotics studies within the university, under the direction of Prof. Tagliasco. Sandini's demonstration was of the anthropomorphic processor which is implemented on a DEC PDP-11/34 and -11/10 interconnected computer system.

Before describing some technical details of the processing methods, I think it appropriate to comment about a distinctly Italian *style* in this project: it relates to the particular image which was the subject of the demonstration. In almost all reported studies on processing pictures written by American, Japanese, or even European researchers, the standard picture is that of a young woman (a German example is mentioned in *ESN* 33-11:446 [1979]). Two faces in particular have become famous in an anonymous way: the Bell Labs' secretary in American reports and her counterpart in reports from Japan. The SIS group, on the other hand, uses a copy of "Boy with Fruit", the late Renaissance masterpiece by Caravaggio. According to Sandini, this decision to avoid the mundane standard was deliberate.

Back to the processing: a model of the retina has been constructed in collaboration with Prof. Lamberto Maffei of CNR's Institute of Neurophysiology in Pisa. In this model, a receptor in the plane of the retina is located at alternate intersections of a set of lines (radiating from the center of the retina) and a set of concentric circles (centered on the same point). The figure shows such a system based on 8 radial lines and 5 concentric circles, and indicates that, by locating points at half the intersections, the total area is divided into pseudohexagonal regions. In the actual SIS model, there are 256 equally spaced concentric circles and 2,048 symmetrically arranged radial lines, leading to 2^{18} pseudohexagonal regions, with a receptor at the center of each. The signal (light) intensity is averaged locally over each region. Over a small central region, the intensity is assumed to be uniformly distributed. In effect, a mosaic of contiguous cells has been organized. According to Sandini, this model matches the human optical system quite well. In particular, the model implies that the linear resolution is finest at the center and becomes continually coarser toward the periphery. In the actual visual cortex, it is known that a number of receptors, from 5 at the center to about 100 at the periphery, are combined to form a single node whose output is relayed to the brain along an optic nerve fiber. A polar-to-rectangular transformation of the data is thought to occur in the region of the cortex, as is a convolution-like operation which determines the eventual angular resolution over the field. Because of the variable resolution of the basic data in the system, the "width" of the convolving function is presumably adjusted according to the radial position in the field.



A simplified diagram, showing 5 concentric circles and 8 radial lines, indicating the pseudohexagonal regions centered on alternate intersections.

Both the coordinate transformation and the convolution operations in SIS's system are being studied by Sandini and others in the group. The currently used transformation provides the desirable (and realistic) characteristic that shapes are held invariant under rotation (except for quantization effects), but it has the undesirable and unrealistic property that the output shape of an object depends upon its position in the original field of view. Distortion is much more severe than simple perspective variations.

The convolution question is more a matter of engineering convenience than a basic problem: Presently, they use a "Mexican-hat" function as the convolver; that function is defined as the algebraic difference between two normalized, zero-mean gaussian functions with unequal variances. The question they are trying to answer is how many different output resolution planes should be implemented; they now have 3 planes. Different average resolution results from different values of the ratio of the variances of the two elemental gaussian functions, while the smaller variance is being adjusted in accordance with the radial location in the field of view.

Is the anthropomorphic approach to image processing worthwhile? As yet, there is no "good" answer to that question, but in the context of the robotics problem, it was suggested that I consider the following: Dexterity includes both a visual component and a manipulation (or motor) component, with the ratio of relevance between the two being a function of the task. In total, a "dexterity quotient" has been proposed to measure the performance of robots. The reference level of 100 is assigned to the "human robot"—whatever that might be; but, as of a few years ago, the best industrial robots had ratings between 10 and 15. Does that imply that the "human robot" is handling the visual component better than the best non-anthropomorphic processor? Probably. I might add: Would use of a suitably designed anthropomorphic processor improve the robot systems' characteristics? Maybe. (Philip Fire)

METEOROLOGY

CLIMATE RESEARCH AT THE UNIVERSITY OF EAST ANGLIA

The Climate Research Unit of the School of Environmental Sciences at the University of East Anglia in Norwich, England, was founded in 1972 by Prof. H.H. Lamb, who headed it until his recent retirement. He was succeeded by Prof. T.M. L. Wigley. Lamb is the author of an impressive two-volume set of books on climatology entitled *Climate: Present, Past and Future.* He is writing another book, *Climate and History and Modern Man,* which is scheduled for completion during the spring of 1981. It is being written for a wider readership and will be published by Penguin.

With a staff of over 30, the Climate Research Unit is one of the larger university climate research laboratories in Europe. It may be unique in that, in addition to climatologists, it also has historians and geographers on the staff studying the relationships between climatic events or climatic variations and historical events (*ESN* 33-12:503 [1979]). The laboratory is also endeavoring to assess the effects of climatic variability on modern society. Only one course is taught in climatology. At the present time seven graduate students are in residence working on PhD thesis research projects.

In contrast to most research groups in the UK, a large percentage of the funding for the Climate Research Unit comes from "soft" money. The breadth of the funding base is unusual. Three government agencies, two private foundations, and two industrial companies, all from the UK, provide funds in support of various climatic research projects. Support also comes from US sources including: the National Science Foundation, the Office of Naval Research, the Department of Energy, and the Rockefeller Foundation.

The general aims of the Climate Research Unit's programs are:

(1) To help establish a detailed and reliable record of the climate of the past, and to analyze these data so so as to improve our understanding of past and present variations in climate and the physical causes of these variations.

(2) To monitor present-day climatic development on a global scale by assembling the data published by appropriate institutions all over the world.

(3) To study in detail the North Atlantic-European sector of the northern hemisphere with particular reference to the North Sea region.

(4) To use the knowledge acquired to do what is possible toward developing practical advice for the future.

(5) To investigate the effects of man's activities on climate today and in the future, and to study and advise governmental agencies and industry on the impact of climate on man, society, and agriculture by means of investigations of events in the historical past and events occurring in the present.

One of the most rewarding and interesting studies underway consists of the reconstruction of atmospheric circulation patterns during abnormal seasons for the period from approximately 1500 AD until about a hundred years ago (when enough suitable weather data became available in parts of Europe to begin to draw weather maps). Comments on the weather are extracted from diaries, letters, ships' logs, commercial records,

and other historical documentary sources and are used to infer atmospheric circulation patterns for the eastern North Atlantic-European sector. For some situations such as the period when the battle of the Spanish Armada took place, there was enough weather data recorded to permit the development of quite detailed sequential weather maps for the English Channel in particular and the areas in and around England in general. One interesting source of climatic data are the cloud formations depicted by Dutch landscape painters of the period which might give indications of the weather when the paintings were made.

The climate of southern Britain is being reconstructed for the past 50,000 years. Large aquifers of very ancient water have been found in the chalk beds near London. C_{14} dating indicates that some of the water may have been *in situ* for as long as 50,000 years. London has an ever-increasing need for more fresh water. The possibility of pumping out and utilizing this antediluvian water has raised a number of questions concerning whether the aquifer would be naturally recharged and, if so, what climatic conditions would be needed for the recharging. By studying the age distribution of water presently within the aquifer, one can obtain some idea as to the times in the past when water entered the aquifer. Then, if the climate record can be reconstructed and water of different ages correlated to types of climate, it may be possible to forecast whether the present climatic regime would have a precipitation balance that would recharge the aquifer.

Two approaches are being taken to reconstruct the past climate, in particular, the rainfall rate. In the first approach, a collection is being made of radiometric dates of cave calcite formations (stalagmites and flowstones) in many caves that exist in southern Britain. The growth of these deposits requires active ground water recharge and so indicates periods of water surplus in the hydrologic balance. The second, more promising, approach is to use proxy data from fossil insects and pollen. The floral assemblages reflected in pollen deposits were controlled by both temperature and precipitation. The assemblage of beetles, on the other hand, has been found to be controlled primarily by temperature, and C_{14} dating of fossil beetles can be used to reconstruct the temperature record. The influence of temperature can then be taken out of the pollen record leaving the precipitation record. Wigley reported that the laboratory had been working on this very difficult problem for several years and probably would continue a major effort for several more years.

Lamb and others at the institute, as well as many other researchers, have been working on the relationship between climatic regimes in northern Europe and oceanographic conditions in the North Atlantic. Latitudinal movement of the Gulf Stream and North Atlantic Drift, movement of the position of fronts between major water masses, and the latitudinal waxing and waning of the Arctic ice pack in the North Atlantic are all being related to the climate and weather of Europe.

The institute has a historian studying maritime records to reconstruct climatic and oceanic changes. The first pilot study was concerned with the western North Atlantic area during the period between 1500 and 1700. It is hoped that eventually the whole of the North Atlantic will be covered for the period from about 1500, when the first records began to be kept, until about 1870, when modern meteorological data gathering became widespread. Records came from commercial ships' logs, explorers' logs, fishing records, maritime insurance companies, and various governmental files of the United States, Canada, and European countries. For example, records for the cod fishery off the west coast of Norway indicate the occasional complete disappearance of cod during cold weather extremes when water temperatures approached 2°C. This occurred in the very cold Little Ice Age winter of 1895. Thus, periods of extreme oceanic conditions can be inferred from records of annual catches of cod. The southern limits of pack ice occurrences correlate well with extreme climatic conditions over northern Europe. During one extreme winter in the 18th century, the ice moved southward about 500 miles from its normal position until it was as far south as the Faroe Islands and two polar bears walked ashore and "invaded" the islands. The positions of frontal zones and, sometimes, the edge of the ice pack can be determined from whaling and fishing records.

The institute has been relating climate to agricultural production in England. Sugar beets are an important crop; the size of the crop is closely related to the weather during the spring and summer preceding the annual harvest in the fall. An accurate forecast of the size of the crop that will be harvested can be made in late March each year and plans for harvesting, processing, and selling the crop can be made well in advance. Now that the forecasting techniques have been established,

tested in England, the institute plans to extend the forecasting of sugar beet crops in other countries such as France. The importance of sugar beets in Northern France is apparent; one of the most prevalent road signs there shows sugar beets spilling out of a truck, together with the symbol for a slippery road behind the truck. The institute is looking for other crops for which forecasting might be done economically. It is already being done for cereal crops in some parts of the world. Wigley stated that a likely candidate for study would be the world's coffee crop which can be greatly influenced by the weather.

Lamb has made an analysis of severe storms and related phenomena such as flooding in the North Sea area. For the period since about 1600, the frequency and severity of the storms, and meteorological conditions preceding bad storms are under study. The results are of importance to the design of ocean engineering structures, forecasting, and the design of flood protection devices.

Another study is concerned with investigating short-term climatic events in western Europe within the period of reliable instrumental records. Attempts are being made to define rigorously those events which are of economic importance, for example, interruptions in transport, changes in energy demand, or effects on agricultural and industrial production (*ESN* 34-5:214 [1980]).

An analysis of the frequency and severity of such events is being made to see if changes in frequency have occurred or if any trends are evident with the idea of forecasting the probable recurrence interval. One problem is that of defining or codifying abnormal events so that they can be statistically analyzed and compared. For example, newspaper headlines may hail a storm as being the worst in a century, but each storm has its own characteristics and each may be the worst in some respects but not in others.

The fact that the Climate Research Unit at the University of East Anglia is doing very well indeed on a very high percentage of "soft" funding in a country where the lion's share of university research funding comes from long-term, rather stable governmental funding is indicative of the general excellence and direct applicability of their research products. I am afraid that this short report does not do justice to the breadth, depth, and excellence of the institute's programs. (Wayne V. Burt)

ENVIRONMENTAL RESEARCH IN SAUDI ARABIA

As part of a project on the meterology of sandstorms, I visited the University of Petroleum and Minerals and its associated Research Institute in Dhahran, Saudi Arabia. The university was founded on 5 Jumada I, 1383 (23 September 1963) by royal decree. An American, Dr. Robert King Hall, who is now the senior advisor to the rector of the university, had conceived the idea of a petroleum-related university and pursued its establishment. Three years ago Dr. W.H. Pickering, formerly director of JPL (NASA Jet Propulsion Laboratory), founded an assoicated research institute modeled after the Stanford Research Institute. This organization is just now completing its new home, an ultramodern research building for over 300 scientists.

The university has about 3,000 students and a faculty of 460. The subjects are mainly technical in nature. MS degrees are offered in chemistry, earth sciences, mathematics and physics. Engineering degrees are offered in architecture, and in civil-, chemical-, electrical-, mechanical-, petroleum-, and computer engineering. An MBS is also offered in industrial management. Research is an integral part of the educational process and is used both for its value as a teaching methodology and as a device for keeping the faculty up-to-date in their fields of specialization. My interests brought me together mainly with environmental scientists. Almost all the researchers at the university have a strong desire to maintain professional contacts with US scientists, to cooperate on subjects of joint interest, and to acquire help in establishing research programs. There seem to be ample funds available as evidenced by the amount of new, sophisticated research apparatus and the ease with which new equipment can be obtained. In the Electronics Department, theoretical research on tropospheric r-f ducting is being pursued. Most communication channels in the country are by VHF, UHF or microwave and, because of the climate, electromagnetic "mirages" and other anomalous propagation phenomena are frequent. US Navy programs on refractive index measurements and forecasting are very applicable to the operational problems under study at the university.

Oil spills are another problem under study. The Mathematical Science Department under Dr. William Lehr is

modeling propagation and movements of possible oil spills in the Persian Gulf using tidal currents and wind field patterns. He is eager to meet US scientists with interests in ocean currents of the Persian Gulf. His group also has a sincere interest in techniques to contain oil spills or to protect fragile beach communities from oil. Dr. Huseyin M. Cekirge of the Research Institute is modeling the movements of sand dunes (a hazard to the Saudi highway system) and the associated micrometeorological variables. His work on surface stress and boundary layer dynamics is closely related to the US Navy program on boundary layer processes. He would also welcome a cooperative effort with US scientists.

The experimental work on sand dune measurements was started by Steven Fryberger (now living in Denver) and is being continued by Dr. Kwasi Boffah. The experimental setup in the desert is very impressive and data on sand transport and wind have been collected for several years. Atmospheric research was started by Dr. Winfried Rudloff, who is in the process of acquiring an instrumented Beech King Air airplane for detecting and measuring aerosol, optical, and atmospheric electrical variables. NRL is attempting to establish a cooperative project with him on the meteorology of sandstorms. Visibility conditions during the 5 days of my stay were such that a 5-mile visible range was never exceeded although no wind was present. It seems haze is composed of very small gypsum particles with settling time constants in excess of several days. Maintaining solar collectors free of dust accumulations is a major problem. Dr. Nimmo of the Solar Energy Research Division investigates these problems. His associate, Dr. Mohammed A. Abdelrahman, has been making solar radiation measurements for 4 years and has accumulated an impressive data base on turbidity. Unfortunately the station is not part of the international turbidity network and therefore the data base is not readily distributed.

My visit to Saudi Arabia also brought me to the King Faisal University at the oasis of Hofuf. Its Agricultural Department maintains an excellent observation site for meteorology. I was impressed by the availability of modern instrumentation and the care with which Dr. Arnold Salstad is carrying out the observational program. (Lothar H. Ruhnke, Naval Research Laboratory)

OCEAN SCIENCES

STATION MARINE D'ENDOUME - MARSEILLES

The Marine Station of the University of Marseilles will celebrate its 100th anniversary in 1983. It has a staff of 80 scientists and 44 support personnel. About 60 visiting scientists spend 1 to 6 months there each year and there are usually about 30 students in residence working on their PhD thesis research. (The station also operates a small branch laboratory at La Rochelle, on the west coast of France, with two staff members in residence and several graduate students.)

Students at the university may elect to major in oceanography during their fourth year by enrolling in survey courses in physical, chemical, geological, and biological oceanography. A diploma is given for a fifth year's study (half courses, half research) in marine biology with two options: (1) benthos and geological oceanography, or (2) plankton and primary productivity. Seventeen to eighteen students enroll each year, of whom half are foreigners, usually from developing countries.

The director of the marine station, Prof. J.M. Pérès, was absent the day I visited and my host was the assistant director, Dr. Christian Emig. He indicated that the laboratory has been levelly funded and staffed for the past 10 years and expects to remain so in the immediate future due to space limitations; the last building was added in 1966.

Research in French universities is tightly controlled by government funding agencies. Because of national pride, scientific workers whose research is funded by the government are encouraged to write up their results in the national language and publish papers in French scientific journals. For this reason, some foreign researchers may not know what is going on in their respective fields inside France. To help fill this gap, I have catalogued the projects underway in the Station Marine d'Endoume.

The research organization at the laboratory is divided into 12 divisions. Their fields of endeavor are:

(1) The distribution and ecophysiology of marine invertebrates, under the direction of Prof. André Bordillon. This includes behavioral studies and the nutrition, metabolism, growth, reproduction and rythmics of the species. The group also studies planktonic ecosystems that are perturbed by domestic, industrial, and thermal pollution.

(2) The distribution of production in the pelagic areas of the ocean under the direction of Dr. Hans Minas. This is by far the largest team with 15 members. Included in their studies are the dynamics of both the primary production and the dilution of organic material in areas where nutrients are brought up from the depths or off the land such as in upwelling areas, large scale divergences, and near the coast.

(3) Pollution and protection of the marine environment, under the direction of Dr. Gerard Belan. This includes integrated field investigations of the whole ecosystem from the pelagic plants and animals to the benthos in areas that are polluted by human waste, industrial sewage, or heated effluent; laboratory bioassays of heavy metals and other pollutants including temperature, pollution by industrial muds; and coastal management.

(4) Bioconstruction and biodegradation on hard substrates, under the direction of Dr. Denise Bellan-Santini. The structure and dynamics of marine assemblages on hard substrates, and boring and fouling organisms are studied.

(5) Coral reefs and neighboring environments, under the direction of Dr. Bernard Thomassin. Investigations involve structure and dynamics in polluted and unpolluted coral reefs and in neighboring environments, with emphasis on benthic assemblages.

(6) Benthic production, under the direction of Dr. Anne-Marie Macé. These studies cover the energy balance and trophic network of soft bottom assemblages; and the composition, biomass, production, structure and dynamics of microbenthos and meiobenthos systems.

(7) Microbiology and protophytes, under the direction of Evelyne Vacelet. This includes biochemical relationships between bacteria and unicellular algae; high-speed growth rate in bacteria; and phototrophy and heterotrophy (growth due to photosynthesis and assimilation of organic matter).

(8) Marine biochemistry, under the direction of Dr. Raoul Daumas. Involved here are geochemistry of organic matter at the water/sediment interface in relation to biological activity; and chlorophylls and the substances resulting from their decomposition.

(9) Physiology of crustaceans and shrimp aquaculture, under the direction of Dr. Hubert Cecaldi. Included are the chemical composition of body tissue and the biochemical requirements at different stages of the life cycle; growth rate as a function of various environmental factors; and artificial foods.

(10) Physiology of fishes and fish farming, under the direction of Dr. Alain Abboussan. This involves the physiology of digestion and assimilation at different stages in the life cycle of different fishes; growth rates and weight increments; and artificial food. The species studied are grey mullets, seabass, and sole.

(11) Biology of marine environments, under the direction of Dr. Jean Vacelet. This covers the taxonomy, biology, and ecology of various zoological groups including sponges, brachiopods, bryozoans, phoronids, polychaetes, crustaceans, molluscs, and ascidians; and their histology, ultrastructure, symbiosis, and parasitism.

(12) Marine geology and sedimentation, under the direction of Prof. Laure Blanc-Vernet. These investigations consider the continental shelf, mainly bioclastic bottoms and carbonate sediments; coastal management clayey sediments; foraminifera; and paleoceanography.

This is probably the largest marine biology laboratory in Europe in terms of the amount of permanent staff, as well as the number of visiting scientists. *(Wayne V. Burt)*

MARINE RESEARCH AT THE JERUSALEM ENVIRONMENTAL HEALTH LABORATORY

The Environmental Health Laboratory is a division of the Hebrew University-Hadassah Medical School. For the past 11 years, it has been monitoring biological contamination in the Mediterranean Sea along the coast of Israel. In the absence of the director, Dr. H.I. Shuval, I interviewed his assistant, Mr. Badri Fattal.

This laboratory has concentrated its efforts in monitoring pathogenic organisms on the beaches of Tel Aviv. It has carried out a major program during the past three years in order to model the dynamics of dispersion, dilution, and deactivation of all types of waterborne pathogenic organisms. Laboratory scientists have developed an improved system for using a 2-step organic flocculation technique to concentrate viruses in water. This method enables them to detect dilutions of viruses down to concentrations as little as 2 plaque-forming units in 500 liters of water. The viruses in samples as large as 1,000 liters can be concentrated into 5 ml with a recovery rate averaging 75%.

Their research results indicate that bacteria die much more quickly than viruses in sea water. After massive year-round sampling at 13 near-shore stations stretching

for about 13 km along the coast in the vicinity of Tel Aviv, they determined that about 78% of the positive, unacceptable virus samples were found near beaches for which the bacterial pollution level was considered to be in the acceptable range (less than 1,000 coliforms per 100 ml). Thus the common method of testing for fecal coliforms, to determine whether water is polluted, does not appear to be a sufficient test.

Another interesting result was that 44% of the samples that were tested in summer positively determined the presence of enteroviruses while 56% of those tested during the rest of the year were positive. The same trend shows up in coliform count. It is believed that this is due to the fact that there is more sunshine in summer than in winter. When all the data on coliform count are plotted against mean monthly duration of sunshine, the relation is very nearly linear with a correlation coefficient of 0.93. Salmonella isolations and coliforms were placed at various depths in sunshine and counts were made at intervals of ½ to 1 hour. The death rate was an order of magnitude faster at 5 cm depth than at 1 m depth, indicating that sunshine must be the important factor.

In tests of pollution as a function of horizontal distance from the "boil," where the sewage comes to the surface over the end of the outfall, the percentage of all types of pathogenic organisms tested decreased logarithmically with distance from the boil. The coliforms decreased an order of magnitude faster than the viruses.

Although the scientists at the Environmental Health Laboratory have developed the improved method noted above for concentrating pathogenic organisms in sea water, they have not been able to speed up the very time-consuming process of classifying or identifying viruses, and they feel that shortening the time required for the process is of prime importance.

Badri also spoke about a "MAVA" project in which some bacteria in sea water were isolated that were able to produce a marine anti-viral agent that deactivated viruses. (Wayne V. Burt)

OPERATIONS RESEARCH

ALIMENTARY CRISIS MANAGEMENT IN SWITZERLAND

Switzerland produces about enough food to give each of its 6,300,000 people 1,600 calories per day. At the present time the average Swiss resident consumes 3,200 calories per day. The difference must be imported. In case of a war or other crisis, it is entirely possible that all imports of food would be cut off. Switzerland wishes to be prepared not only for the possibility of being engaged in war, but also for the possibility that it would be the innocent victim of a war in which it was neutral, or that it might undergo some other crisis in which it was deprived of food from outside sources. Switzerland, therefore, is preparing to be self sufficient in providing food to its people.

The obvious first step would be to reduce the demand. The decision has been made that it would be reduced from 3,200 calories per day per capita to 2,400, by a form of rationing which is ready to be put into operation almost immediately. The other two essential requirements are methods of raising the production of food from the 1,600-calories-per-day level to 2,400, and the storage of sufficient stocks of food in inventory to tide the country over during the period when production is not yet as great as consumption. There are presently adequate (or nearly adequate) stores of food for this purpose. Plans call for parts of the transition to take as long as three years.

The sufficiency of food during wartime is one of a set of similar questions of interest to the military which are now being investigated by various universities in Switzerland. Each such investigation requires a specific model, built in a separate research project. Some of the other models are discussed in connection with the University of St. Gallen in the article on operations research at Swiss schools, to appear shortly in *ESN*. The remainder of this article is devoted to one part of this project at Fribourg, namely consideration of the manner in which food production will be increased by the necessary amount. The dynamics of the transition are not discussed here.

One might well ask: if it is possible to make Switzerland self sufficient in food production, why is it not done now? The answer is that it would be

uneconomical. At the present time, it is far more efficient and profitable for Switzerland to import food and to export various types of manufactured goods, such as drugs, which the Swiss produce very efficiently. The problem, then, is how to convert from the present economy to the self-sufficient economy that might be required in a time of crisis.

This problem was solved, after a fashion, during WWII. There had been some planning for this, but of course nothing so sophisticated or detailed or analytical as the present study. A study for a better plan was undertaken at the University of Zürich starting in 1967, and a final report was issued in 1975. The contract issued by the Swiss government for developing the plan was extended and transferred from the University of Zürich to the University of Fribourg in 1975 and has been there ever since. Although the contract will formally come to an end in 1981, it now appears probable that it will be extended for an additional five years. The contract is under the overall supervision of Prof. Jürg Kohlas, head of the Center for Automation and Operational Research, a department in the Faculty of Economics at the University of Fribourg. The detailed implementation of the contract is under the direction of Gustav Egli, a research assistant who has only recently completed his doctorate under Kohlas, his thesis being concerned with this problem and constituting some of the work described below. Egli had studied agricultural engineering at the University of Zürich and then took a master of science degree in agricultural economics at Kansas State University before returning to Fribourg for his doctorate.

The problem is basically a multicriterion decision problem, but has been handled in a clever way so that the basic computation can be performed by a series of classical optimization techniques involving unique criteria. Specifically, the first stage is a linear programming model with two types of variables: the amounts of land to be devoted to various types of agricultural uses; and the populations of various animals (such as pigs) which use very little land, but do make heavy use of other resources such as vegetable foods. The objective function is to maximize the total number of calories produced. Given this maximum number of calories, the second stage is to minimize the magnitude of the inventory required to tide the country over during its transfer to this maximal production of calories.

In practice, of course, to make the problem realistic requires that it become much more complicated than this simple statement. There are roughly 1,000,000 hectares of agricultural land in Switzerland which must be allocated to appropriate uses, often different from those under which it is now employed. A simple maximization and minimization, as described above, would, for example, result in the complete elimination of poultry and pigs, since utilizing feeds such as grain to produce meat or eggs is most inefficient from a caloric viewpoint (an animal typically consumes many calories of vegetable food for each calorie of animal food which it yields). Additional constraints are therefore specified for political reasons or reasons of people's tastes; e.g., there must be a certain minimal production of swine and of poultry. No such constraints are needed for cattle because they can graze on land unsuitable for most other products (and one of the conclusions of the study is that about two-thirds of the million hectares will still be devoted to pasture, with a total decrease in the number of cows of only 7% to 10%). There will also be some slight increase in the total amount of productive land, since some marginal land will be brought under cultivation.

Sugar beets produce a large number of calories per hectare, but medically it is undesirable to have too much sugar in the diet, and so a special constraint is inserted to keep the amount of sugar beets below a stated maximum. A different maximum concerns the capacity of the factories where the sugar beets are processed. Another example: oil-containing seeds such as colza (*ESN* 35-4:150 [1981]) have very high caloric values, but as indicated in the article cited, there are marketing constraints on its use. Colza, incidentally, is an unpredictable crop: there may be very high yields in some years and very low yields in others. A technique known as stochastic programming could be used to take care of this, but Egli has actually taken the more conservative approach of assuming that the amount of colza which is produced from a hectare is the minimum amount that will be produced in any one year with a probability of at least 0.9.

There are also constraints on the minimum amount of fat which must be included in a diet, on the minimum amount of protein, and on the minimum fraction of that protein which must be animal protein (that is, eggs or meat as distinguished from beans or nuts). No special requirements need to be included for things like vitamins and minerals since these appear to be taken care of

automatically by the typical Swiss diet. But there is a special requirement on fats, namely that 25% of all of the fats must be "visible fats." This term refers to butter or vegetable oils, as distinguished from "invisible fat" which for example is consumed as part of meat. This requirement leads to a fascinating story.

It turns out that the present plan calls for approximately 20 kg of potatoes per month per person (a significant increase), but the Swiss might not be willing to eat so many potatoes unless enough visible fat were available to prepare them in the form of their beloved "rösti" (fried potatoes). With this in mind, it had been suggested that the amount of visible fat should be increased to 30%. When the model was run with this new constraint, many unforeseen things happened. To get this extra fat, the computer model indicated that there had to be extra butter; to get the extra butter there had to be extra cattle; because the pasture land was already all in use, these cattle had to be fed on grain cereals such as wheat and corn. The net result was a drastic decrease in the total number of calories available, because a cow tends to utilize 12 calories of grain in producing 1 calorie of butter. Furthermore, this reduction in grain meant that there were less pigs available, and the pigs, while supplying no *visible fats*, produced a large quantity of animal fat. Among the results, therefore, of increasing the percentage of visible fats from 25% to 30% was a decrease not only in total calories, but also in total fats. When these unforeseen consequences of the policy change were explained and understood, the constraint was again revised back to 25%. This seems to me a fine example of the uses of models of this type, and the advantages of the operations-research approach.

There exists a shadow organization for economic defense consisting of a large number of people who are officially on the project but only on a part-time basis. Although the only full-time workers on the project are those at the University of Fribourg, many others are involved—for example, people collaborating by obtaining data, and committees of doctors helping to decide some of the questions mentioned above about fats, visible fats, and sugars. Such people either do not get paid or are paid rather nominal sums, but rarely do they decline the opportunity to serve in such a way.

"The optimal solution," Egli told me, "is not what initially comes out of the computer, but what we have arrived at when we get to the point where nobody objects." I asserted that this was impossible, that there are always special interests who push for a solution which is more in their own favor. One presumes, for example, that the dairy farmers would like to see more fats and more visible fats and the like. Egli acknowledged that this was true, but insisted that he was not referring to these special interests. What happens is that he continues modifying the special constraints, and then in various seminars reports back to the consultative committees and the appropriate government agencies. He feels, indeed, that unanimity among these people can eventually be obtained. Meanwhile the model has already been of considerable utility and is beginning to be employed for special purposes such as the analysis of crises short of wars. What would happen, for example, if imports of specific classes of foodstuffs were to be stopped? And how could Switzerland most efficiently adapt to such crises?

Typically, the major headache in actually doing the study was coping with the data—data were not reliable, they were not in the right form, data from different sources were inconsistent, and so on. Egli told me that 90% of his time was spent worrying about data. When considerable amounts of data were available on, say, the yield of a certain crop, he would build a regression model and use it to predict the yields under crisis circumstances. The model itself was simple enough, being a straightforward LP model, although it was moderately large (1300 rows, or constraints, and 1400 columns, or structural variables). It was run on an IBM 370/145 computer which belongs to the administration of the Canton of Fribourg, although it is often used by the university.

I was impressed by the extent to which so simple a model can be so useful in helping a government deal with what appears to be a critical problem. (Robert E. Machol)

OPERATIONS RESEARCH IN BELGIUM—PART II

Perhaps the Belgian OR Institute best known to Americans (partly because many well-known Americans have spent sabbatical years there) is CORE, the Center for Operations Research and Econometrics. The Université Catholique de Louvain, as it is called in French, or the Katholieke Universiteit Leuven, as it is called in Flemish, was established more than 500 years ago in the town of Louvain (or Leuven). As indicated in Part I of this article, (*ESN* 35-3:181 [1981]) that university became bilingual over the

period 1930-1970, when it split into two separate universities, the Francophone part moving 20 km south to Louvain-la-Neuve. CORE was established at the university 15 years ago by Jacques Drèze, with support from both the Flemish and French-speaking branches; Drèze is still an active member of the permanent staff of CORE. When the university split, CORE elected to go with the French-speaking part. At present, both universities are sizeable, there being some 20,000 students at the University of Leuven and 15,000 at the University of Louvain, as it is still called, although it is actually situated in the town of Louvain-la-Neuve.

The current research director of CORE is an expatriate Englishman, Lawrence Wolsey, who took a bachelor's degree in mathematics at Oxford and then a PhD in mathematics at MIT; he taught for a while at the University of Manchester (UK), then took a research fellowship at CORE, and has now become a permanent resident of Belgium. After 6 years as a chargé de cours, or associate professor, he is now a professor in the Engineering School at the University of Louvain (UCL). Starting in the middle of 1981 Paul Champsaur will become the research director for a 2-year period.

The language at CORE is English. CORE consists of 3 rather disparate groups: operations researchers (which in CORE is virtually defined to mean people working in mathematical programming), mathematical economists, and econometricians. The three groups are remarkably isolated from one another; each, for example, has its own seminar. What they have in common is an interest in mathematics, and beyond that a faith in mathematics. When CORE was started, people were quite optimistic that mathematical economics could solve real problems, and all of these people still retain some of that optimism.

The staff at CORE consists of about 15 permanent academics, 15 to 20 assistants (who may be younger people working on contracts), and 15 visitors. Some of these are on sabbaticals, with most of their salary paid by their home institution and CORE perhaps contributing travel money, while others are on fellowships or salary. CORE offers a number of fellowships with a stipend of 500,000 BF (approximately $15,000) plus transportation for a period of 9 months. These are available for postdoctorates or for faculty sabbaticals. Most of the permanent staff also teach at the University of Louvain, the OR people in the engineering faculty and the economists in the business faculty. The dean of engineering at the university is Guy de Ghellinck who was the father of OR at the University of Louvain, where he gave the first courses in this subject many years ago. In recent years, however, he has been tied down by administrative duties, and he no longer is active in the field of OR.

The University of Louvain, through CORE, has worked out a cooperative arrangement with the London School of Economics and the Rheinische Friedrich-Wilhelms University of Bonn in Germany for a "European doctoral program in quantitative economics." The student does his preliminary work, including the equivalent of a master's degree in economics-econometrics, with perhaps some additional statistics and mathematical courses, at one of the three universities, and then does a year of advanced work at a different one of the three universities. The language of this work is English regardless of the school. The dissertation is then written at either of the two universities the student chose for the work. The advantages of a student seeing another environment during or immediately after the doctoral work is an old idea in the US, but is not nearly so common in Europe.

CORE has obtained some external funding (besides that which is given by the university) from the Belgian government and from the EEC. Most of this is to support the modeling of energy systems and the implementation of large-scale linear programming techniques, including decomposition techniques, especially as applied to energy problems.

Wolsey's research is largely in integer programming, and especially on the analysis of heuristics and on the theory of duality as applied to integer programming. For example, one might consider the depot-location problem and utilize a "greedy" algorithm, consisting of a heuristic in which, at each point, the next depot is assigned (located) in what would be the best fashion if there were no others; that is, an algorithm which suboptimizes at each decision point. There might be a theorem to the effect that such a heuristic gives a solution which is at least 60% as good as the true optimum. It is then necessary to have some other method of computing the upper bound. Duality theory may give such an upper bound; the dual variables might be the prices which customers are prepared to pay. Duality theory is also especially useful in post-optimality analysis, that is, in manipulating a solved problem, to find out how the solution changes when some of the parameters of the problem are changed.

Another permanent member of the faculty is Yves Smeers, who studied engineering at Liège in Belgium and took his license in economics at the University of Louvain (before the split) and his PhD in OR at Carnegie-Mellon University. Smeers has been at CORE since 1972, originally continuing his doctoral research on geometric programming, but eventually becoming a specialist on energy and, typically for CORE, the applications of mathematical programming to energy. These applications involve decomposition, that is methods of taking very large linear programming problems such as arise in complex energy models and breaking them down into a number of small problems each of which can be solved easily, and then finding methods of putting the solutions together again at the end to find the true solution to the overall large problem. Such decomposition techniques in a linear programming problem context were pioneered by Dantzig and Wolfe in the US some years ago. In particular Etienne Loute, working with Smeers, has done excellent decompositon work; and James Ho from the Brookhaven Laboratory in New York, working at CORE, has developed some powerful methods of nested decomposition applied to staircase-structure programs (*ESN* 33-11:479 [1979]). They are using software called MPSX 370, which is a modification of IBM's MPS mathematical programming package. It requires 1 megabyte of storage, which is readily available on UCL's IBM 370/158 computer. The software can handle nonlinear objective functions, but all the constraints must be linear.

I also talked to Tony Van Roy who is spending two years at CORE while on leave from his permanent position at the University of Leuven. He worked for a while at UCLA with Geoffrion and Graves on decomposition techniques, and has continued research in that area. He is particularly interested in "cross decomposition", which combines Benders partition (basically a primal decomposition technique) with Lagrangian relaxation (basically a dual decomposition technique). He has applied this to the facility location problem mentioned above and reduced the computation time required by a factor of 20.

Van Roy also told me about current OR work at the University of Leuven, where there are large OR groups in both the faculty of applied science (what we would call engineering) and in the faculty of economics. The former offers a 1-year postgraduate program to students who are engineers and who have completed a 5-year license. That program results in the degree of Master of Industrial Management; about 35 students per year get this degree. The language of instruction is Flemish. The faculty of economics has a large MBA program run jointly with the University of Chicago in which the language of instruction is English. There appears to be considerable exchange of both faculty and students, and more than 100 MBAs per year are awarded. Students who have their license in economics or an equivalent degree from somewhere other than Belgium can complete the program in 1 year, but others such as engineers with a 5-year degree require 2 additional years for the MBA. A similar program has been worked out between Brussels University and Boston University.

An unusual organization where good OR is being done is the European Institute for Advanced Studies in Management (EIASM) located in Brussels, a mile or so from the city center. English is the official language of the Institute and French is the second language.

EIASM was founded in 1970 by a committee from 8 countries in Western Europe chaired by Gaston Deurinck, president of the Belgian Fondation Industrie-Université and the present chairman of the managing board of EIASM. It was originally funded by the Ford Foundation, but as is often the case with that foundation, the money stopped after 5 years, and EIASM is now supported by public and private sources in Belgium, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, and Sweden (Great Britain, Spain, and Switzerland are no longer included in this group). About 1/3 of the funds come from Belgium through the Ministry of Education. Other funding sources may be direct or indirect: examples of "indirect" funding include paying very high fees for students (which is done by Germany) or paying the salary and travel expenses of staff members (which is done by Holland). The institute now operates on a budget of BF 40M (about $1.2M) per year.

The Institute for International Management in Berlin is similar to EIASM in many ways but EIASM differs, in one specific way, by being specifically European. It is designed especially to contribute to the development of European teachers and researchers in the management disciplines and to encourage cross-cultural and international communication within Europe among management scientists. Towards these ends, it has developed working contacts with many management teachers and researchers in Europe. It encourages the development

of European doctoral education in management and provides assistance to them; it encourages and coordinates joint research projects in management; and it organizes seminars, workshops, and courses on applied research and on disciplines relevant to management. "Management" here is broadly defined, including such disparate fields as organization behavior, accounting, and operations research.

The former director of EIASM, Alain Bensoussan, devoted all of his time to the job; the present director, Philippe Naert, who holds a 5-year appointment, spends half of his time at EIASM and half at his home university in Antwerp. Naert, originally an electrical engineer, took an MSc in OR at UMIST (Manchester, England) and a PhD in OR at Cornell. EIASM has a small permanent staff, many of whom spend only part of their time there, and a large number of temporary workers who are hired for periods of up to 2 years. Among well-known American OR experts who have been there recently are Stanley Zionts, Salah Elmaghraby, and Robert Graves. Next year's American visitors, well-known to the American OR community, will be Igor Ansoff, Warren Hausman, and Linus Schrage.

The institute has developed and maintained a large network of relations among more than 150 universities, business schools, and research centers throughout Europe. Among the unusual activities made possible by such a network are the semiannual seminars at which some 40 doctoral students from various countries (mostly the nearby countries such as Belgium, Holland, France, and Germany, but occasionally students from farther away, including a few from Poland subsidized by a special Ford Foundation grant) come to read their thesis proposals and have them criticized. In addition, some doctoral students spend considerable periods of time at the institute under the direction of one of its staff members.

The institute also runs numerous workshops, seminars, and courses—in a "course," 3 or 4 experts lecture to 20 or 30 students while, in a "workshop," everyone is on an equal footing. Such meetings may run from 1 to several days and those attending may be academics or managers.

I spoke at some length to Alexander H.G. Rinnooy Kan, a member of the permanent staff. Rinnooy Kan took a Master's degree in mathematics at Leiden and a PhD in math in Amsterdam in 1976. A year later he received a chair in OR at Erasmus University in Rotterdam.

Rinnooy Kan spends half his time in Rotterdam and the other half in Brussels. His primary area of research is combinatorial optimization, especially as applied to scheduling. He does much of his work jointly with J.K. Lenstra of the Mathematics Centre in Amsterdam; Rinnooy Kan, Lenstra, and G. Lawler (Univ. of California, Berkeley) are now working on a book on scheduling. He also has some very interesting ideas on global optimization in nonlinear programming. It was mentioned earlier (in Part I) that Hansen was using mathematical programming to improve cluster analysis; Rinnooy Kan is using cluster analysis to improve mathematical programming.

The greatest problem in nonlinear programming is that a local optimum may not be a global optimum. That is, there may be a point which yields a higher value of the objective function (in a maximization problem) than any nearby point; but at a distance there is a still higher function value. Rinnooy Kan uses a modification of a technique frequently employed in the past (for example by S. Reiter many years ago) of choosing points at random in order to find nearby local optima. In his modification, the function value is checked first and, if it is not relatively high, it is discarded. If the function value is high, a single steepest-descent step is performed to find a local near-optimum before a new point is picked. At the end, cluster analysis is performed on all of these local near-optima, and for each cluster, the steepest-descent analysis is applied to find the local optimum. The purpose of this technique is to avoid the repetition of the time-consuming process of finding the same local maximum over and over again.

Rinnooy Kan also works in "portfolio analysis." I find this word being used with quite a new meaning all over Europe and the United States. Until very recently it referred to a portfolio of investments, but now it may refer to almost any collection of actions, such as a portfolio of products or a portfolio of marketing techniques.

Rinnooy Kan told me one interesting anecdote of some applied OR which he had done on production scheduling for an airplane manufacturer. They had found a near-optimal schedule by heuristic methods which turned out to be far better than the rule-of-thumb methods which were then being used. However, the management decided not to implement it on the grounds that the workers probably wouldn't like it.

There are a number of other Belgian centers of research in OR, but I did

not have the opportunity to visit them. In Namur, at a small private Catholic French-speaking university of 5,000 students, there is some active research on nonlinear programming in the Mathematics Department under Prof. Nguyen van Hien and J.J. Strodist; and Prof. Jean Fichefet works in linear programming at the Informatics Institute there. There is a major center for research in OR at Liège. Finally, largely because of its high degree of industrialization, there is in Belgium considerable industrial OR activity, but I did not have the opportunity to visit any of those facilities. It is clear that much good OR is being done in this country, although it suffers drastically from the isolation imposed on the OR groups, especially the academic OR groups, by the many divisions discussed in the first part of this article. (Robert E. Machol)

PHYSICS

SOME SOLID STATE PHYSICS IN DENMARK

COPENHAGEN

In 1819 at the University of Copenhagen, H.C. Oersted performed the earliest recorded experiment on electromagnetism. In his honor, the center for all of the university's work in the natural sciences is now called the H.C. Oersted Institute; its associated student body numbers about 2500. For administrative purposes, the physics research activities at the institute are organized into two groups: Physics Laboratory I for research in superconductivity, magnetism, gas lasers, and cryogenics; and Physics Laboratory II for research in atomic physics, radiation effects on materials and structural properties of materials.

My host there was Prof. A.R. Mackintosh, an Englishman with a PhD from the University of Cambridge who came to Denmark via the Ames Laboratory of Iowa State University. He is now president of the European Physical Society (EPS) for 1980-81. Previously he was the first chairman of the Condensed Matter Division of the EPS, was a president of the Danish Physical Society, and from 1971-76 was director of the Danish Atomic Energy Commission Research Establishment RISØ. Mackintosh, who is now concentrating on his EPS commitments, told me that the outstanding contribution of the EPS is to bring the physicists from all European countries together. Before the EPS was organized, it was not usual for scientists from different countries to form a community, but now collaboration has become natural.

Formation of the EPS has stimulated scientific meetings. In the last decade, the conference situation has changed completely and now there is a full calendar, comparable to that in the US. All of the divisions of the EPS are now organizing annual conferences. Collaboration and cooperation also extend to publications; the publication of the European Journal of Physics was launched with the help of the Institute of Physics in London. Mackintosh thinks that the initial formation and growth period of the EPS is past. During his term of office, he intends to concentrate on the maintenance of economic stability in the organization and to put other activities such as the scholarship program and the lecturer exchange program on a sound and established base.

At the time of our talk, Mackintosh and O.K. Andersen (Technical Univ., Lyngby) had just published a 95-page review article, "The Electronic Structure of Transition Metals," which has 28 figures and almost 200 references. The article, which discusses crystal potentials and energy band theory, cohesive and magnetic properties, band structures, and Fermi surfaces, was written as a contribution to a Festschrift for Prof. D. Shoenberg (Univ. of Cambridge). After his term as president, Mackintosh intends to return to research on the rare earths, continuing to investigate magnetic structures and excitations by neutron scattering. (See *ESN* 34-7:355 [1980] and *Phys Rev B* 20 1105 [1979])

LYNGBY

A short train ride from Copenhagen is the engineering part of the University of Copenhagen, the Danish Technical University (DTH). The DTH (See *ESN* 34-11:511 [1980]) was founded in Copenhagen by Oersted in 1879 and moved to its present location near Lyngby in 1961. Professor J. Mygind, whom I had met at the International SQUID meeting in Berlin, told me about the Physics Laboratory I of which his group is a part. The laboratory has 15 scientific staff, 10 technical staff and 5 workshop-office staff. Research is divided into 5 general groups: electromagnetic waves and resonances in metals, superconductivity, molecular lasers and spectroscopy, tunneling effects, and band structures.

The scientific staff members are on a yearly appointment (with 4 weeks holiday) with duties divided thus: 50% teaching, 10% administration, and 40% research. Support for research comes from the state through the DTH, and

from the Danish National Science Fund. Travel support comes from a separate fund. The superconductivity work has had good support—1 million Danish Kroner (∿ $150,000) for equipment in the last two years. This group, unlike some of the others, is not directed by a single person. Instead, the group is free to make a choice of scientific direction by discussion among the members.

Efforts of the superconductivity group have resulted in the development of microbridge oscillators operating at frequencies to 69 GHz, tunnel junction amplifiers working at 35 GHz, and a low-loss microstrip configuration of a remotely adjustable impedance transformer for use with Josephson devices. Mygind told me that the Josephson effects work was changing direction, at least partially because the junctions have such low impedence that it is difficult to operate without affecting the junction in a highly nonlinear fashion. Previously concerned with parametric devices, the group is moving toward a study of solitons.

In the electromagnetism group, R.A. Gordon and C.M. Larsen have recently measured acoustic attenuation in ferromagnetic metals at liquid helium temperature and fields up to 16 kilogauss. Using a standing-wave technique at frequencies of a few MHz, Gordon and Larsen simultaneously determined both the velocity of sound and the absolute value of the acoustic attenuation from measurements of the position and width of the resonance in a 0.57 mm-thick [111] oriented disk of single-crystal nickel. They claim to have reported the first observation at low temperature of the maximum in attenuation which occurs at fields less than the saturation field.

Interesting features of the attenuation peak and the associated minimum in the sound velocity are that: the phenomena must be related to the magnetization process, since it has been observed only in ferromagnetic materials; the attenuation peak is not observed when the magnetization takes place only by domain wall motion; and the maximum can be observed at field intensity levels where the magnetization is not complete. Gordon and Larsen claim that no existing theory explains their measurements which have been submitted for publication in *Solid State Communications*.

ROSKILDE

Twenty miles west of Copenhagen is the town of Roskilde (pop. 50,000) located at the head of Roskilde Fiord. Five kilometers north of the city is the RISØ National Laboratory (named after the peninsula). Formerly a laboratory operated by the Danish Atomic Energy Commission, the institution became a national laboratory under the Ministry of Commerce in 1976. In addition to long-term research in the areas of reactors, materials, environment, and agriculture, the laboratory has undertaken work on nonnuclear energy sources. This is the only national laboratory in Denmark and it employs approximately 800 persons of whom 250 are scientists. Funding of the laboratory is essentially from the state; some additional funding has been received recently through industrial contracts from the European Common Market countries. In the last fiscal year, the state's contribution was DKr 100M (∿ $17M).

Dr. H.B. Miller, head of the Physics Department, told me that work in the department was divided into meteorology, solid state physics, and plasma physics. Meteorology studies started in 1956 with concern about the distribution of radioactive waste in the atmosphere. The work broadened into general air pollution studies, the impact of wind on buildings, and lately has included wind energy. As part of this latter subject, the meteorology group has produced a wind atlas for Denmark and also operates a test station for small windmills. On the approach ride to the laboratory entrance, I passed this rather unusual installation of a variety of wind power devices all whirling in the wind. RISØ is also participating in the construction of two 600 kW windmills in Jutland.

The plasma physics research is all carried out as part of the European Fusion Program and is coordinated with Euratom from which at least 25% of the funding is obtained. The fundamental physics work is a study of plasma instabilities for which a small Q-machine was constructed. This machine, which has a discharge current of 60 A, giving an electron density of 10^{11} cm^{-3}, is used primarily to study whistler waves. Other plasma work is concerned with methods of fueling a plasma, principally by shooting pellets into the center of the plasma. A small Tokamak and pellet gun are available for this work.

The solid-state research is centered about the DR3 (10 MW) reactor which was purchased 20 years ago for use in reactor technology studies. The reactor has turned out to be useful for neutron beam experiments and is capable of results competitive with those obtained with newer reactors. The beam tubes are tangential to the core so that the neutron must be

scattered out by a scatterer placed near the reactor core. Three of the tubes use water scatterers; the fourth uses liquid hydrogen which provides cold neutrons with a distribution peaked at 15 meV (λ = 2.34 Å) to the triple axis spectrometers in the reactor hall. Cold neutrons are also piped via a curved tube from the reactor hall to another triple-axis spectrometer in the experimental hall, where the neutron flux peaks at 10 meV (λ = 2.86 Å) and has a useful range of 2.5 - 15 meV.

The spectrometers are controlled by computer (PDP-11) which allows programming of the sample temperature and magnetic field as well as the necessary angles. Miller told me that, by spring of 1981, 6 triple-axis spectrometers are expected to be operating, of which 4 will be using cold neutrons. Pressure equipment is also available for use in the 4-300 K range: piston type cells for hydrostatic pressures to 40 kbar and a gas pressure cell for pressures to 4 kbar.

Long-term interests of the neutron scattering group are in rare-earth compounds and phase transitions. Recent experiments have been on spin waves in Ho_2Fe_{17} and Ho_2Co_{17}, magnetic properties of Nd and HoSb, and magnetic ordering of TbOOH and YbOOH. In 1978, experiments at this facility provided evidence for soliton modes in the one-dimensional ferromagnet $CsNiF_3$. (*Phys Rev Lett* 41, 1137 [1978]) At the time of my visit, these experiments were being extended.

Although neutron scattering is the dominant tool, an intense x-ray beam emanating from a rotating anode machine has recently become available. This 12 kW facility, a joint project between RISØ and the University of Copenhagen, uses a Cu or Mo anode. One of the two ports is fitted with a triple-axis spectrometer, the other with a simple diffractometer with which adsorbed monolayers have been studied. Much of the work with the x-ray facility is preliminary to synchrotron radiation studies, usually carried out at Hamburg (FRG) with the storage ring DORIS. (*John R. Neighbours*)

LANDING IN LUND—SOME PHYSICS IN SWEDEN

During a recent scientific liaison visit to Denmark, I visited the University of Lund in Sweden. Founded in 1666, it is the second oldest university in Sweden. After WW II, the university enrollment grew rapidly from a prewar student body of several thousand to a maximum of 23,500 in 1969, afterwards declining slightly to its present size of approximately 19,000. Originally closely linked with the Lutheran church, the university is now supported by the state.

Prof. Lars Hedin, head of the Solid State Theory Group which was formed in 1971, told me that the group now numbers 10, of whom 3 are currently occupying temporary positions at other institutions. The main interest of Hedin's group is many-body excitations from incident photons with energies up to 1 kV. Hedin has published a general article (*Journ Phys* 39 C4-103 [1978]) in which he discussed the static and dynamic effects of removing a core electron from different alkali metals. Work in this area is being extended to the transition metals.

A 500-Mev storage ring is being designed and constructed at the university. The actual construction is under the supervision of Dr. Michael Eriksson; calculations are being directed by Dr. W. Stiefler. A total workforce of 10 persons is engaged in this 5-year project which was begun in 1977. Many of the components were completed when I visited, but the future was somewhat uncertain. The original site for the machine was the physics building, but Eriksson would like to move it to a larger building in order to have more working space for the users. The final decision will depend on the university research committee.

Eriksson and Stiefler are very proud of the injector, a 100-Mev race trace microtron built at the university. Similar in concept to a cyclotron which has been sliced in half and had the two magnets separated, the machine has so far achieved half of its designed 20 mA current.

The storage ring, with bending magnets of 1.2-m radius and a ring diameter of approximately 9.4-m, is considerably smaller than the one in the UK at Daresbury, (*ESN* 35-1:36 [1981]). This design is one with 100-ps electron bunches driven at 500 MHz by RF cavities excited by special-purpose klystrons which were built in Stockholm at the Kungliga Tekniska Högskolan. The first beam line, for use in the 10-200 eV (50-1000 Å) range, is scheduled for completion in 1982, but will undoubtedly be delayed because of the uncertainty of the storage ring site.

Later in the day I met Prof. H.G. Grimmeiss, head of the Department of Solid State Physics, who described his research in semiconductor physics. Grimmeiss is the motivating force for

a group of about 25 people including 12 research students. This is a large group for Sweden and it had a correspondingly large budget of one million Swedish Kronor ($210,000) in 1980.

Grimmeiss' research is the study of deep level impurities in semiconductors formed by the addition of impurities *not* in a column of the periodic table adjacent to that of the semiconductor. Ordinarily, extrinsic semiconductors are formed by the addition of small amounts of an element from an adjacent column in the periodic table to an elemental semiconductor (such as P to Si). This so-called doping is a much-used technique to modify the electrical conductivity of the host material. These shallow impurities have a hydrogen-like spectrum of energy levels with the ground state energy lying relatively close to the band edge so that, at ordinary temperatures, the impurity sites can be considered to be highly ionized. Doping Si with Al or P creates shallow impurities with ionization energies of only 60 or 45 meV, respectively. In contrast, deep-level impurities which are created by the addition of elements not in adjacent columns, have typical ground-state levels several hundreds of meV from the band edge, and are usually only partially ionized at ordinary temperatures. For example, doping Si with Au gives an impurity level near the middle of the band gap, ~ 540 meV from the edge of the conduction band.

The importance of deep-level impurities was pointed out to me by Grimmeiss. He told me that the impurity level position controls the free carrier lifetime τ and that a deep-level impurity may have the same effect on τ as a shallow one at much lower (by a factor of 10^{-6}) concentrations.

In two recent papers (*J. Appl Phys* 51 3740 [1980] and *J. Appl Phys* 51 4212 [1980]), Grimmeiss and his coworkers presented results which show that both S and Se create two dominant donor levels in Si which are distinguished as *A*-centers and *B*-centers. The activation energy has been determined for each of the two donants. The concentration of the A and B centers was found to be approximately the same for both impurities and the similar thermal behavior of the two types of centers suggested that both centers might have excited states.

In a paper scheduled for publication in *Physical Review*, Grimmeiss and B. Skarstam have reported the spectral distributions of the photoionization cross sections for the S and Se-related donor centers. They find the distribution in the 0.2-0.8 eV photon energy range to be rich in detail, some of which is temperature dependent, and have interpreted these results as evidence for two types of excited states: Rydberg-like states, and those originating from the multivalley nature of the conduction band. The shapes of the significant features are seen to be Lorentzian with the energy position of both centers (4s in the middle of the band gap, ^{2}s with a binding energy of approximately 0.3 eV) believed to be independent of temperature. For further details, the reader should consult their lengthy, detailed paper containing 18 figures. In other related work as yet unpublished, Grimmeiss has studied the deep-level ground and excited states in Cu-doped CdS. He is also preparing a review article on measuring techniques for deep-level impurities.

Since the impurities in a semiconductor have great effect on its electrical properties, Grimmeiss is having elaborate facilities constructed for the preparation and characterization of samples. He hopes that his research will make it possible to tailor semiconductor devices with the proper amounts and kinds of impurities in order to optimize their performance.

This subject is growing to some extent as a result of the research by Grimmeiss who has pioneered the experimental techniques of deep level spectroscopy and deep level transient spectroscopy, and who has served as the principal host for two invitational "Lund" Conferences. This year represents a break in tradition—The Third Lund International Conference on Deep Level Impurities in Semiconductors will be held on 26-29 May in Salisbury, Conn. (John R. Neighbours)

NEWS & NOTES

UK UNIVERSITY LECTURERS FACE JOB CUTS

Some 3,000 university dons in the UK may be in line for redundancy payments (lump-sum payments in connection with involuntary job terminations) of up to £30,000 ($69,000) over the next 3 years as universities cut back their staffs in the face of higher education's worst-ever cash crisis. Payments in this range will be necessary to buy out the lecturers who have tenure. The government has set aside £20 million to finance such payments, and the universities may also draw on their own £70 million reserves.

The drastic cuts, announced in a public expenditure white paper last month, are behind this gloomy prospect. Next year's grants to higher education will fall by 3 percent in real terms. The universities, however, which also recently lost subsidies for overseas students, will have to reduce spending by at least 10 percent and possibly by as much as 15 percent by 1983-84. Because some 72 percent of university spending is on labor costs, and because the dons account for about half of that amount, they are bound to be in the firing line.

The University Grants Committee (UGC), which hands out government funds, is considering four possible plans to distribute next year's grants:

(1) Force some universities to shut down by giving them a zero grant. This course is considered the most unlikely simply because it would be too controversial.

(2) Spread the misery evenly. This would mean that the universities would make their own decisions on where to cut. The danger in this is that they would be piecemeal cuts.

(3) Remodel the British university system by creating a hierarchy. Universities at the top would continue to teach a full range of subjects and maintain adequate research laboratories and postgraduate teaching. Second-class colleges would offer a restricted range of subjects, but would continue research and postgraduate work in those areas. Those at the bottom would become liberal arts colleges on the American model, offering undergraduate courses only.

(4) Draw up a "hit list" in each subject and "advise" the universities to close them. The UGC has no power to give orders, as universities are technically private institutions, so the advice would be accompanied by a reduction in grant equivalent to the spending of the weak departments.

Some combination of the last three approaches is expected. The UGC's difficulty is to decide which departments should be closed. One possible criterion, very attractive to academics, is to look at the money each department wins in research grants and contracts from commerce and industry, government departments, and the various research councils.

NMR CLUE TO METAL BONDS

Chemists who synthesized a series of unusual molecules featuring multiple carbon-phosphorus bonds are now looking at the ways in which these molecules bind to metals.

The researchers, from the Organometallic Laboratory of Sussex University, UK, have made a variety of complexes—based on metals such as platinum and tungsten—which contain an intact C = P double bond (*JCS Chemical Communications*, 1981, p. 199).

Besides having pure research value, the work makes the first step towards finding out exactly what useful chemical work these molecular curiosities can be made to do. The researchers (H. Eshtiagh, Mohd Jamil Maah, and Michael Taylor) used NMR (nuclear magnetic resonance) spectroscopy to identify the new compounds and investigate their bonding.

The scientists found that the C = P molecule, known as a phosphaalkene, binds to the metal through its phosphorus atom, in agreement with results for similar molecules containing P = N and P = N double bonds.

Investigations of the reactions of the new complexes could yield new reagents for organic or organometallic synthesis. Meanwhile, other researchers are continuing to isolate new small, unusual molecules (*New Scientist* 87, 1243, p. 649 [1981]), and are using NMR to investigate their structure and bonding.

TOWER OF POWER WINDS UP TO FULL OUTPUT

Europe's first solar power station based on the principle of the tower collector should achieve an output of 1 MW within the next few months. Construction of the station, called Eurelios, ended recently at its site in Sicily. Built by a consortium of German, French and Italian companies, at a cost of £5 million, Eurelios has 182 solar collectors in its power field. A computer controls the direction of reflectors so that they reflect sunlight towards a radiation receiver in a central tower. The collected energy is stored in a salt reservoir before it is used to generate steam. This drives a turbine which in turn drives a generator producing electrical energy. Tests on the various components of Eurelios have so far proved successful, says Messerschmitt-Bolkow-Blohm, the German contractor. When the station's full output starts to supply the Italian national grid, engineers will gain experience about the station's automation systems and how feasible the idea is for other sites.

CARBON FIBERS FOR AIRBUS

A demonstration Airbus Industrie A300 aircraft is now flying with a rudder made of carbon fiber reinforced plastic (CFRT) in place of the standard light-alloy structure. Measuring over 8 meters long and 2 meters wide, the new rudder is the largest single carbon-fiber element undergoing trials on the aircraft at present.

Its weight-saving over the conventional metal rudder is 45 kg or about 20 percent. Performance of the unit is being studied in a program of flight tests, and a second composite rudder is expected to begin in-service testing on a Lufthansa A300 next month.

The use of such elements is part of a weight-saving program on A310 and A300 airbus aircraft aimed at achieving a higher payload.

ONR COSPONSORED CONFERENCES

Norwegian Electro-optics Meeting 1981, Vinstra, Norway, 29 March-1 April 1981.

Conference on Interfaces in Composite Materials, Liverpool, UK, 1-2 April 1981.

2nd International Low Temperature Biological Microscopy and Microanalysis Conference, Cambridge, UK, 6-9 April 1981.

8th International Gas Bearing Sympsoium, Leicester, UK 8-10 April 1981

International Seminar on the Role of Finite Element Methods in Radiation Physics, London, UK 23-24 April 1981.

Symposium on "Polymer Liquid Crystals—Science and Technology," Portofino, Italy, 18-22 May 1981.

International Conference on Osteoporosis, Jerusalem, Israel, 31 May-4 June 1981.

International Sympsoium on Locational Decisions (ISOLDE II), Skodsborg, Denmark, 15-18 June 1981.

Conference on "Modification of the Surface Properties of Metals by Ion Implantation," Manchester, UK 24-26 June 1981.

VIth International Bioelectrochemical Conference, Kibbutz Kiryat Anavim, Israel, 28 June-3 July 1981.

9th International Conference on Operational Research, Hamburg, Germany, 20-24 July 1981.

International Symposium on Advances in Polymer Characterization, Durham, UK 13-17 July 1981.

International Symposium on Hydrodynamics in Ocean Engineering, Trondheim, Norway, 24-28 August 1981.

4th International Symposium on the Chemistry of Novel Aromatic Compounds (ISNA 4) Jerusalem, Israel, 30 August-4 September 1981.

NATO Advanced Study Institute on "Static and Dynamic Properties of the Polymeric Solid State," Glasgow, UK, 6-18 September 1981.

EUROPEAN VISITORS TO THE US SUPPORTED BY ONR LONDON

SPRING 1981

Visitor	Affiliation	Navy Lab./Org. to be Visited
Prof. Evan-Wyn-Jones	Dept. of Chemistry, Univ. of Salford, UK	NRL, Marine Physical Lab., Scripps
Prof. J.W.R. Griffiths	Loughborough Univ. of Technology, Loughborough, UK	NOSC, NRL, NUSC (April/May)
Dr. D.E. Packham	School of Materials Science, Univ. of Bath, Bath, UK	NSWC, White Oak (May)

ONRL REPORTS

C-6-80

U.R.S.I. Symposium 1980 on Electromagnetic Waves
by T.C. Cheston and David K. Cheng

The 1980 International U.R.S.I. (Union Radio Scientifique Internationale) Symposium on Electromagnetic Waves was held in Munich. The report reviews the symposium and some of the papers.

R-2-81

Chemical Research at the Institute für Strahlenchemie, Mülheim by A. Paul Schaap

The Institut für Strahlenchemie (Radiation Chemistry) which is located in Mülheim, FRG, was founded in 1958 as a unit attached to the Max-Planck-Institut für Kohlenforschung (Coal Research). The Institute for Radiation Chemistry is involved in research in a variety of areas including: (1) chemical effects of ultraviolet radiation, λ-rays, and high-energy electrons on organic and biological systems; (2) new methods of synthesis; (3) organic and organometallic photochemistry; and (4) theoretical chemistry.

Research at this institute on the use of vesicles to deliver inositol hexaphosphate (IHP), an allosteric effector of hemoglobin, to red blood cells (RBC) may result in procedures for dramatically increasing the oxygen release capacity of RBC. Potential applications include an improved O_2 supply to tissues under low O_2-partial pressures in air such as at high altitudes. Preliminary experiments with rats have shown that incorporation of IHP into the RBC enables the rats to adapt to reduced O_2 partial pressures.

R-6-80

Laser Research in Ireland, Germany and Austria
by Richard S. Hughes

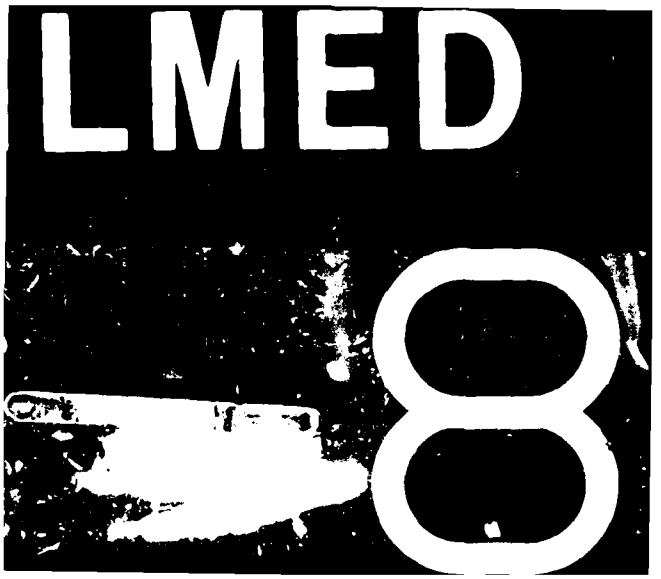
This report contains short summaries of Electro-optics (EO) research and comments on the activities observed. The discussions include the research programs, key personnel, trends, and general observations. All of the EO research known to be going on in Ireland is reviewed; only part of the EO work in Germany and Austria is covered.

R-8-80 Optical Data Processing in Europe by David Casasent

This report contains short summaries of some current activities, accomplishments, and problems in France, the Federal Republic of Germany, and the United Kingdom in the field of optical data processing. Both university and industrial research laboratories are included. In all instances, the emphasis is on optical image and signal processing.

R-9-80 Area Report - Developments in Microwave Antennas and Applications in Sweden, Denmark, and Norway by T.C. Cheston

This report summarizes research and development work in microwave components, applications, antennas and related devices, found in Sweden, Denmark, and Norway. It describes work at Sweden's Royal Institute of Technology, National Defence Research Institute, Chalmers University and the L.M. Ericsson Company; Denmark's Technical University; and Norway's Technical University and associate government research organizations.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